THE JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY OF ENGLAND

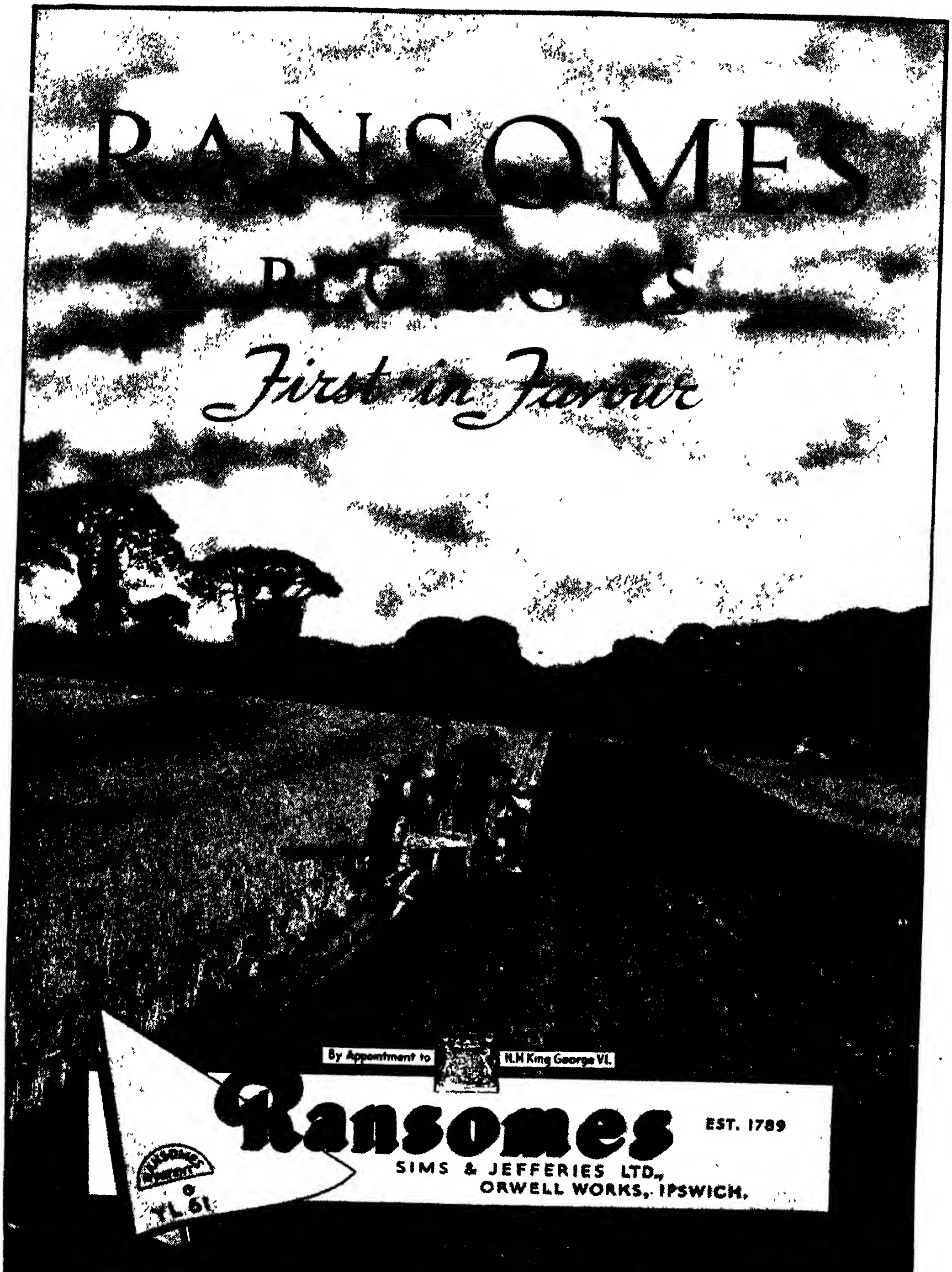
VOLUME 106.—107

1945—46

PRACTICE WITH SCIENCE

LONDON:

JOHN MURRAY, ALBEMARLE STREET



RANSOMES
First in Favour
By Appointment to H.M King George VI.
Ransomes
EST. 1789
SIMS & JEFFERIES LTD.,
ORWELL WORKS, IPSWICH.

CONTENTS.

President for 1946: VISCOUNT BLEDISLOE, P.C., G.C.M.G., K.B.E. *Frontispiece.*

FARMER'S GUIDE TO AGRICULTURAL RESEARCH IN 1944.

SPECIAL ARTICLES.

EXTRACT FROM THE SOCIETY'S BYE-LAWS

(*Dating from the Foundation of the Society*) :—

"The Society will not be responsible for the accuracy of the statements or conclusions contained in the several papers in the Journal, the authors themselves being solely responsible."

PRESIDENT FOR 1946
VISCOUNT BLEDISLOE, P.C., G.C.M.G., K.B.E.

CROPS AND PLANT BREEDING

I. CROP STATISTICS AND FUTURE POLICY.

The official statistics of crop acreages, livestock population and estimated production of the principal crops in England and Wales during 1939-44 show the part played by home agriculture in feeding the people of this country, as well as demonstrating the fundamental changes in the balance of agricultural production in terms of crop output (Ref. 1). It has been estimated that in recent years approximately 70 per cent. of the nutritional requirements of the country has been produced at home, and this has been accompanied by a 70 per cent. increase in the total tillage acreage.

The outstanding features of the great change in crop production during the war years have been the 86 per cent. increase in the cereal acreage and the 116 per cent. increase in the potato acreage, both of which were responsible for more than doubling the output of these crops, thus showing how yields have been maintained. In addition, the total acreage of vegetables (excluding potatoes) for human consumption has increased by nearly 64 per cent., while the acreage under all other crops such as fodder crops, etc., shows a substantial advance. In many crops, including the cereals, acreages have reached the highest figures ever recorded.

The figures for the various types of grassland and grazings are significant in showing a 43.5 per cent. increase in temporary grass of all types, and a 38 per cent decrease in permanent swards for grazing and mowing. Although there has been a slight increase (3.8 per cent.) in the area of rough grazings, there being still 5¾ million acres of land in this category, it should be noted that part of this increase is due to the changed utilization of rough areas, and it is impossible to draw a hard and fast line between rough grazings and permanent grass because of the reclassification of the grasslands of the country.

With the war in Europe at an end, the Minister of Agriculture has issued a statement on national policy for the next two years. According to this statement, although in the immediate future the country must maintain the food production efforts of the war, there will be a change of emphasis on the products, and there will be a decrease in cereals, potatoes, sugar beet and vegetables and increased attention to livestock products. This will entail a reduction of the 1944 tillage acreage of 11,600,000 acres to 10,950,000 acres in 1946-47, although it is hoped to increase slightly the arable acreage at the same time. The most important development is the proposed expansion of temporary grass from 2,970,000 acres to 3,850,000 acres to cater for the increased output of livestock products, while it is hoped at the same time at least to maintain the area under fodder crops.

The significance of these changes is obvious; they constitute a step towards the more balanced agriculture suited to the conditions in this country. If the large increases in world

food production which are visualised as necessary for the adequate feeding of the people are to be implemented, it is difficult to see how a considerable degree of national specialization in food production, based on environmental suitability, can be avoided. The United Nations Interim Commission on Food and Agriculture has published its first report, and has proposed that a permanent organization should be set up at an early date to solve collectively the problem of food shortage, and collect, analyse and disseminate information on nutrition, food and agriculture in addition to promoting and recommending national and international action regarding research.

In this country several reports on agricultural policy and reconstruction were published in 1944, and it is interesting that the majority refer to the necessity of developing a balanced agriculture based on environment, the maintenance of soil fertility, and the nutritional requirements of the people (Ref. 2). The generally accepted opinion may be summarised in the following extract from a statement unanimously adopted at a conference convened by the R.A.S.E "The fundamental purposes of long-term policy should be the proper use and management of the agricultural land of this country for the production of the foodstuffs which it is best fitted to provide and which are most required to satisfy nutritional needs while maintaining the fertility of the soil, the raising of the standards of rural life and the increase in the rural population."

II. NATURAL GRAZINGS AND GRASSLAND MANAGEMENT.

The foregoing considerations inevitably imply an adequate and efficient use of the natural agricultural resources of the country. Of these resources, the natural and artificially maintained grazings and grasslands constitute a vastly important component, and there is widespread concern in many countries that neglect and wrongful exploitation have allowed the natural grazing lands particularly to degenerate to a condition which can no longer be tolerated.

This position is clearly reflected in two symposia published by the Imperial Bureau of Pasture and Forage Crops dealing with grassland husbandry and fodder plant production in various parts of the world (Refs. 3 and 4). The problems and their answers are not merely domestic considerations for the countries concerned, but they often offer useful illustrations of the trends in agricultural thought and policy which may be applicable elsewhere. An illustration of this may be seen in the grassland management experiences in New Zealand, where between the years 1916 and 1940 there was an increase of 160 per cent. in the cow population and 25 per cent. in the sheep population despite a decrease of 34 per cent. in the acreage of swedes and turnips, and a 41 per cent. decrease in the area under mangolds. The livestock increase was, however, accompanied by a five-fold increase in the area under hay and silage which is regarded as being the significant concomitant, although there has been a great expansion of the practice of top dressing pastures. Top dressing with phosphate and lime has demonstrated that there is a close relationship between this practice and high carrying capacity and productivity per acre. Experiments have shown that even where 4 cwts. of superphosphate were applied to swards at sowing, more than this amount was returned through the manuring of the grazing animal in one year. Harrowing of grassland to spread the animal droppings is consequently regarded as an important part of grassland management, and it is worth noting that heavy surface cultivations as such have failed to show any benefit to the sward under the conditions of the New Zealand experiments.

In this country the importance of an adequate policy for the upland and hill grazings is emphasised by the report of the Committee on Hill Sheep Farming (Ref. 5). It is estimated that one sixth of the total agricultural area of England and Wales comes in this category, and before this war between 20 and 25 per cent. of the total ewe population, together with an undetermined number of cattle, were kept on these lands. The welfare of the hill areas

is of vital consequence to the agriculture of the country because of the dependence of the lowland sheep industry on the hill sheep population, but the Committee concluded that "there is a deplorable waste of human and material resources" in the hill areas due to economic instability. This waste can be stopped only by the application of the best scientific and practical knowledge, and the first need is to improve the stock-carrying capacity of the grazings so that they can fulfil their function of supplementing the resources of the lowlands for rearing stock. This function will become of greater importance as the use of new leys and the adoption of alternate husbandry develop, and it will be necessary to improve the lower enclosures and intakes to provide more winter keep for sheep and cattle. The Committee recommend that this should be done by ploughing and reseeding where possible, and by liming, manuring and good stock management where ploughing is not practicable.

The key to the whole problem is the stimulus and means to improve the grazings and conserve soil fertility. Effective and efficient improvement is dependent largely on the outcome of research applied to a large number of problems of which the following are outstanding—the breeding of suitable herbage plants: the design of appropriate power-driven drainage tools: the application of the most efficient systems of liming and phosphatic manuring: the design of cheap methods of bracken eradication: methods of controlled heather management: the question of hill sheep diseases and flock management, and the rôle of cattle. But the urgent need of the restoration of soil fertility is of paramount importance; this is stressed by the Scottish Committee in their report on hill sheep farming in Scotland (Ref. 6), and also in Ref. 8.

III. ALTERNATE HUSBANDRY AND LEY FARMING.

The application of alternate husbandry and the development of the most efficient system of ley farming and rotational practice are matters which are commanding the attention of agriculturists throughout the world (Ref. 7). The problems and their most effective solution are, of course, to a large extent economic, but they are also largely concerned with the vital matter of building up and maintaining soil fertility and the productivity of the land. It is obvious, therefore, that every country and agricultural area needs separate consideration according to its natural resources, environmental conditions and economic problems. In Sweden, for example, although the temporary ley is utilised for contributing the bulk of the winter fodder, there is a recent tendency to sow pasture leys for the production of summer fodder outside the usual rotation. In Germany, some of the most eminent grassland experts do not subscribe to the testament of the temporary ley, but instead they support the idea that good permanent grass, well managed and under suitable conditions, improves with age and produces the most valuable meat animals and milk of the highest fat content. In some of the newer agricultural areas of the world—the U.S.A., Canada and Australia—the development of efficient alternate husbandry systems is largely dependent on finding suitable forage plants and increasing the livestock population, while over large areas in the tropics it will be necessary to solve a number of formidable problems before stable peasant farming based on livestock can be visualised and, even then, it remains to be seen whether this will ever develop into something approaching true ley farming.

The position in this country with regard to the application of the principles of alternate husbandry and ley farming has been discussed from time to time in these articles and needs no further mention at the moment. There are, however, certain questions of a more restricted and technical nature affecting rotational practice which are worth considering.

The effect of herbage plants on the fertility and structure of the soil is of direct practical importance in relation to the best associations of the constituents of ley mixtures

and the optimal time for leaving leys down under various soil and climatic conditions. It is considered that the most important reason for introducing perennial grasses into crop rotations is that under all climatic conditions the improvement of soil structure develops to a higher degree under perennial grasses than under any other type of vegetation. In devising rotations, therefore, it is important not only to produce the most economically efficient leys, but also to establish and manage temporary swards in a manner which results in the most beneficial effect on the soil. These two requirements obviously do not always coincide, but the production of forage above the soil, and the effects of root growth in the soil, are the two main features of ley management.

Experiments have been conducted in various parts of the world to determine the time necessary for a ley to exert its maximum beneficial effect on the soil, and also on the time taken to destroy this effect after ploughing out. Woburn experiments in this country suggest that a one-year ley can have a beneficial effect on two following crops of corn, but the general conclusion from experiments in all parts of the world is that the full effects of the ley will be reached in two years in a moist climate and four years in a dry climate, with a similar period for the destruction of these effects by cultivation. It is obvious, however, that soil type and the crops grown will also affect these critical periods.

The important practical implications are stimulating a great deal of work on the behaviour, rate of development, penetration, spread and decomposition of the roots of herbage plants, as well as the effects of various types of management on these characteristics of root systems. The results of this research must have important repercussions on systems of ley farming, the most efficient herbage plant species, the best mixtures and the most efficient management. The problem of sward deterioration with age must also come under consideration here ; as to how far this deterioration may be due to the development of a sod-bound condition, which is commonly associated with the dominance of creeping (rhizomatous) grasses at the expense of the tufted species and clovers, and to what extent it is due to a lack of balance in available soil nutrients which can be remedied by cultivation, fertilizers and the sowing of legumes.

Climate, of course, holds the key position in regard to many of these considerations involving farming systems, rotations, livestock enterprises and the botanical composition of leys. But under any set of climatic conditions, all soil factors assume importance and more knowledge is necessary concerning soil fertility and productivity and the requirements of particular crops before the best systems can be evolved under particular environments. However, all these technical questions, and many others such as weed control, the incidence of fungal diseases and insect pests, and the health of livestock, are little more than academic scientific problems unless the economic considerations are such as to encourage improved systems of farming. The general economic reasons for adopting alternate husbandry are :—

1. It provides one of the best methods, or one of the necessary processes in the best combination of methods, of maintaining soil condition necessary for continued production.
2. It provides the most economical method of securing a necessary increase in physical production per unit of land.
3. It provides the most economical method of securing a varied production of crops and livestock to provide an adequate and satisfying dietary.
4. It may provide one of the best methods of securing a high output per man and thus of raising the standards of earnings and living in the agricultural community.

IV. HERBAGE PLANT STRAINS.

Trials with Aberystwyth strains of herbage plants have been conducted at ten centres in Leicestershire, and afford an interesting example of the behaviour of these strains under these particular conditions. It must be stressed, however, that the assessment of behaviour

was based entirely on eye judgment. Eight of the fields were broken up from old grass for direct reseeding, and two were foul old arable destined for seeding without a nurse crop. The seed was sown in the spring or in August after a bare fallow, and appropriate fertilizers were added. The swards were grazed early and almost continuously throughout the grazing period each year, with rest intervals during the winter (Ref. 9).

The grass species used were perennial rye grass, cocksfoot, timothy and meadow fescue. The trials confirmed the impression that the first named species is the most successful for soils of medium to good fertility, although cocksfoot and timothy-dominant swards were successful under conditions suitable to these grasses. Meadow fescue, on the other hand, did not prove itself to be a useful species.

The Aberystwyth strains showed up very well in comparison with the commercial and New Zealand strains, and they demonstrated an ability to withstand hard grazing, a good ground-covering capacity, an absence of any extreme peak in production and the power to prevent white clover dominance. These characters of the Aberystwyth strains are, of course, of great importance in herbage plants exposed to intensive grazing management. S. 23 perennial rye grass, S.50 timothy and S.143 cocksfoot were outstanding as leafy grazing types and excellent swards were obtained with S.23 as the only grass, or as the dominant strain, with either of the other two.

The most attractive swards were formed, however, with S.23 dominant and S.50 timothy and either S. 143 or S.190 cocksfoot also included. As far as the clovers were concerned, S.100 white clover fulfilled all the requirements and there was no need to include a red clover in leys up to 5 years duration. S.100 possibly did not compete with the very leafy grass strains as successfully as wild white clover, and the latter may be necessary for the longer leys, although S.100 was still in full production at the time the report was written.

V. THE PLACEMENT OF FERTILIZERS DRILLED WITH SEED.

In Ref. 10 attention is drawn to the risks and advantages attendant on the practice of drilling fertilizer with seed, and it is stated that the results obtained will be affected by the type of drill used, the character and condition of the fertilizer, and the soil and weather conditions at seeding time. If a non-combine drill is used there is considerable danger of damaging both the drill and the seed, and if this method is employed the drill should be cleaned immediately after use, the seed and the fertilizer should be mixed immediately before sowing, and a granular fertilizer should be preferred to a powder.

Although it is preferable to use a combine drill, there is still some danger in sowing the seed with the fertilizer because the seed becomes coated with the fertilizer and lies in contact with it in the soil. Therefore, the best method is to deliver the seed and fertilizer through separate coulters, and in this connection it is stated that the best results are obtained with root crops (which appear to be very liable to damage by contact with fertilizers) when bands of fertilizers are placed alongside the seed rows and not in contact with, or below, the seed (Ref. 11).

There is experimental evidence to support the view that phosphatic fertilizers give better results when drilled with the seed than when broadcast. Experiments with a granular phosphatic fertilizer applied to spring oats and barley in this country showed an average increase in the yield of grain and straw from combine sowing twice that from broadcasting, although in one of the experimental centres broadcasting gave slightly better results (Ref. 11). Although oats, barley, turnips, swedes, sugar beet and mangolds have all been shown to benefit by drilled phosphatic fertilizers, sugar beet and mangolds are known to have been injured, and beans and peas appear to be the most likely crops to suffer from heavy dressings. Cereals, on the other hand, apparently are much less susceptible to contact with fertilizers

but even they may show a delay in brairding due to combine drilling; this, however, may be soon compensated by more rapid and luxuriant growth which is seen in a higher rate of tillering, better weed control and higher yield.

In all cases there is evidence that potash fertilizers are better not used in a drill, while there is greater risk from drilling a compound or mixed fertilizer than from the same amount of fertilizer constituents applied separately. In any event heavy dressings of fertilizer should not be drilled, and it is maintained in Ref. 11 that the full benefits of combine drilling can be obtained only if the plant's requirements for nutrients can be included in 2 to 3 cwt. of fertilizers.

The above statements are in general supported by experiments with soya beans in the United States of America (Ref. 12). In these experiments all the fertilizers used delayed the emergence of the seedlings to some extent, irrespective of the kind or amount of fertilizer, its placement, or the soil type and moisture content. Generally speaking, however, the emergence was delayed in proportion to the kind of fertilizer and the rate of application when used in contact with the seed, and in soils of low moisture content the delay tended to be greater when the fertilizers were applied in contact with the seed in comparison with the fertilizers sown in bands.

VI. POTATOES.

A Joint Committee of the Agricultural Improvement Council for England and Wales and for Scotland have reported on "the measures required to ensure that scientific knowledge in respect of the production and use of seed potatoes is fully applied in practice, and to make such further recommendations as to the growing and storage of potatoes as the Committee think desirable." A summary of this report has been published by the Ministry of Agriculture (Ref. 13).

The causes underlying poor yields and wastage in a crop which was valued at £14,000,000 before the war is a matter of great concern, and the problems connected with the growing of adequate seed supplies and their efficient distribution are worthy of serious consideration by the whole community. It is most important to ensure that healthy and vigorous stocks of seed are maintained by an efficient certification scheme and that the proportion of healthy seed planted is materially increased. There still appears to be considerable lack of knowledge and appreciation of the significance of using healthy seed (at the present only about 50 per cent. of the total seed planted in England and Wales is certified), and the importance of the incidence and dangers of fungal diseases, particularly Blight, and eelworm needs to be more widely known. The Committee's report also stresses the damage and loss to the crop due to tuber and storage diseases, particularly when the tubers are left in the clamp for long periods of time as has happened during the war.

There are useful published accounts of the important considerations in relation to healthy and pure stocks, and the reaction of varieties to virus and other diseases (Ref. 14 and 15). There are very distinct varietal responses to different viruses, and the severity of the symptoms and their effects, as well as the susceptibility in the field, are not sufficiently appreciated by growers. For example, although the Leaf Roll virus causes similar symptoms in all varieties, and there are as yet no immune varieties, considerable differences exist between varieties in the effect of the virus and the ease with which infection takes place in the field. Arran Banner is amongst the least affected varieties and it also resists field infection, but Majestic, although field resistant, is affected to a greater degree, while Arran Consul and Dunbar Cavalier are both severely affected and very susceptible in the field.

The various viruses which cause Mosaics and other symptoms are more complex in their reactions with different varieties. There are six recognised viruses of this type (X, B, A, Y, F and G), some of which are relatively unimportant from the practical point of view,

while combinations of certain pairs of these viruses produce distinct symptoms. The varietal response to these viruses is not always a mosaic; some varieties are "carriers," while others react to particular virus combinations (*e.g.* X & A) by top necrosis thereby giving the so-called "intolerant" or "field immune" varieties such as King Edward and Epicure. Naturally, varieties which are intolerant to individual viruses cannot show symptoms due to combinations of viruses which occur in other varieties. It is important from the agricultural and breeding points of view to realise that there are certain of this group of viruses, such as Y, to which there is no known varietal intolerance, while others, such as F, are found commonly only in particular varieties.

The importance of crop losses due to wastage in the clamp and during storage was mentioned in the Committee's report, and a summary of the causes responsible for these losses is given in Ref. 16. According to this account Blight is undoubtedly by far the most important direct cause, and enormous losses may result by the inclusion of blighted tubers in the clamp, due in most cases to the lifting of the crop while the disease is still active on the haulms. Other frequent causes of wastage are faulty clamping, which often leads to clamp collapse because of rotting tubers: mechanical damage during lifting: and Dry Rot infections. Less frequently wastage may be due to Pink Rot, Water Wound Rot, Black Leg, Common Scab, slugs, wireworms, eelworms, and tuber infections leading to tuber discolouration. In most cases the various forms of fungal, insect or mechanical damage lead to break down of the tubers by soft rot, with consequent overheating and clamp collapse. The obvious and most efficacious precautions against such wastage are the exclusion of blighted tubers from the clamp, the prevention of rain and frost damage before covering and of clamp damage during the winter, and the prevention of clamp overheating in the spring.

VII. SUGAR BEET.

The use of sheared or segmented sugar beet seed has increased considerably in the U.S.A. during the last few years, and there has been widespread interest in this practice in this country. Segmented seed sprang into prominence in certain areas in America largely because labour shortage made it necessary to introduce as high a degree of mechanization as possible into the handling of the crop. The use of segmented seed is concerned with the problem of mechanical thinning, and the main concern is the uniform deposition of the seed at the proper rate under conditions suitable for quick and even germination so as to ensure a full and even plant. A good seed bed is especially important when using segmented seed because of the lighter seed rates and the dependence on the successful establishment of the individual plants, while shallow drilling and the use of a reliable fungicidal seed dressing are also desirable. These precautions are, however, largely wasted unless the drill is capable of depositing the seed uniformly as required, and considerable experimentation is in progress in America for devising the most efficient type of drill (Ref. 17).

There are certain problems in connection with the field germination behaviour of segmented seed which need careful examination (Ref. 18). Certain aberrations and abnormalities in germination may result from imperfectly segmented seed, or seed which has come away from its "corky" covering, and these abnormalities appear to be due largely to the seedling breaking away prematurely from its surrounding tissue as the seed germinates. The consequence of this is sometimes the production of bent and twisted seedlings which make little or no progress to the soil's surface and a resultant loss in initial plant establishment. In certain cases seedlings from single seed units, whether segmented or not, may be unable to emerge through the soil as satisfactorily as those from whole seed with more than one germ, a condition which is particularly liable to occur from deep sowing

or the presence of a surface soil crust. It is suggested by the authors of Ref. 18 that if a satisfactory dropper drill was designed, whole seed, with 90 per cent. producing not more than two seedlings, could be distributed at two-inch spacing and give as satisfactory conditions for mechanical thinning as does segmented seed. This work suggests, and there is support from investigations in this country, that the outer covering (" cortex ") of the so-called seed performs an important function in germination, and that consequently it may not be as easy to obtain satisfactory seedling establishment under poor soil conditions with segmented seed as with whole seed. It is also worth recording that American experiments on the effect of treating sugar beet seed with synthetic growth substances have failed to show any benefit to seedling emergence, vegetative growth, sucrose content, purity or yield of roots (Ref. 19).

VIII. MANGOLDS.

The National Institute of Agricultural Botany has published the results of three years' trials with twenty-eight selected strains of mangolds, the strains having been selected from over fifty which had been under observation for three years (Ref. 20). Although the trials were not conducted to study the relationship between yield and soil type, manures and previous cropping, there were certain associations between yield and growing conditions which are worth noting. There was some suggestion that Black Aphis, and the leaf mosaic which is transmitted by this insect, are among the chief obstacles to high yields in the drier parts of the country, and there was evidence that one strain appeared to show resistance to the disease. The data from the Institute's sub-stations indicated also that certain strains are better suited to some parts of the country than others, and there is considerable scope for the regional testing of the types available to the farmers.

The real agricultural value of the mangold depends on the yield of feeding matter, the cost of production, and the keeping quality of the roots. These considerations are primarily dependent on the root type, and particularly on the dry matter content, total weight of roots and root conformation. In general it was found that the Golden Tankards as a class were low yielding both as regards roots and dry matter : that Kirshe's Ideal was outstanding in yield of dry matter : that certain strains within the particular root types were superior to others in that type : that small top strains yielded below the average in dry matter : that strains with few lateral roots were rather easier to lift and much easier to clean : that certain strains, notably the Golden Tankards, had better than average keeping quality, although there was not sufficient evidence to relate keeping quality with percentage of dry matter or size of root

The report concludes by considering the reasons for the inferiority of the English strains in yield of dry matter to the continential strain Kirshe's Ideal. It is considered that the earlier influence of the sugar beet on the continent centred attention on the yield of sugar in mangolds, while in this country interest was centred more on saving labour and the appearance and conformation of the root. The result has been the development of small top strains with a satisfactory root shape and size, but, of an inferior dry matter content. In computing rations and planning the acreage devoted to mangolds, the main consideration, however, must be the yield of feeding matter per acre and the nutritive value of the individual roots.

IX. CEREALS.

(*a*) *Wheat* An interesting account of the baking quality of some home-grown varieties of wheat and the effect of growing conditions on this quality is given in Ref. 21. It was possible to place the wheats in three groups according to their quality, the best ones being good for English wheats but still below the average for commercial bakers' flour, and including such varieties as Extra Kolben II, Atle, Holdfast, Warden and Yeoman II. The

second group included wheats of average standard for English grown, while the third group gave flour of extremely poor baking quality and comprised such varieties as Desprez 80, Scandia, Squarehead's Master, Chevalier and Ironred. It should be mentioned, however, that the placing of some of the varieties was changed by the addition of "improvers," but the quality of others was unaffected by this treatment.

A comparison of the grain characters and baking quality of the varieties grown with normal and intensive manuring showed that some exhibited a slight increase in protein content due to intensive manuring, while others exhibited a marked protein increase, but in all cases there was only a small change in the quality of the flour. On the other hand, there was a marked change in the grain type of certain varieties when grown in the Fens, the grain being shrivelled, thereby reducing the flour extract, while the flour itself was of a dingier colour.

b. Oats. Eight years' trials with eleven varieties of oats, each grown for three or more seasons, have given clear indications of the behaviour of these varieties under the comparatively high rainfall conditions of Bangor, North Wales (Ref. 22). Eagle and Onward were outstanding from the point of view of total yield of grain, although the latter variety has a considerably higher percentage of husk. Star and Record were next in order of yield, with Star giving the better quality grain. For strength of straw, which is of such importance under high rainfall conditions, particularly where the crop is grown on ploughed up grass, the best six varieties in order of merit were S. 84, Early Miller, Eagle, Marvellous, Record and Star. Under the conditions of these trials the time of ripening is of great significance because on the lowlands a few days' advantage in earliness may mean the difference between cutting a standing or a laid crop, while in the uplands it may determine success or failure in harvesting. The earliest variety in these trials was Early Miller, which was followed by Marvellous, Royal Scot and Onward. Resistance, Eagle and S.84 were the latest maturing, but it should be mentioned that Resistance is only suited to very early spring sowings.

The Welsh Plant Breeding Station have placed on the market a new variety of spring oat (Ref. 23). This variety, designated S.200, was obtained from the cross Victory X Radnorshire Sprig, and is suited to soils of average to below-average cropping capacity. The grain is black and usually has 26-28 per cent. of husk : the panicle is of the open type and the straw of medium length. S. 200 may be regarded as a variety of reliable cropping capacity, and on soils of moderate fertility it will give high grain yields of average quality, and a good grain:straw ratio.

c. Barley. Maltsters and brewers are showing considerable anxiety concerning the combine harvesting and farm drying of barley which is destined for the malting and brewing industries (Ref. 24). There is a strong prejudice in the brewing and malting trade against farm dried barley, while the use of the combine harvester for barley means that the crop is handled quite differently from the methods used with the reaper and binder. For the most part barley which has been combined is not field matured in the same way that barley which is harvested with the reaper and binder is, and owing to lack of storage facilities there is the complication of a high proportion of the barley crop being marketed over a restricted period at the beginning of the season. Silos with drying plants have been erected in various parts of the country to try and cater for the quicker and earlier delivery of the farmers' crops, but this means a possible blending of different crops showing individual malting characteristics, and also a type of drying and handling which is not suitable to the maltsters and brewers.

These matters are of direct concern to the grower who is dependent on disposing of the bulk of his barley crop to the maltster. Combine harvested barley should be handled with the requirements of the trade in view, and in particular farm drying of the grain should be done with the greatest care. Correct drying and storage of malting barley are vital, and if the

interests of home-grown barley are to be safe-guarded, the maltsters' requirements must be studied. However, the wet harvest of 1944 showed that there was one advantage for combining. The barley that was standing in the field waiting for the combines was less damaged by the weather than if it had been cut and left out in the shock when, of course, it is more difficult for the ears to dry when the weather affords the opportunity. Consequently, if combine barley is efficiently and adequately dried it may be marketed in considerably better condition than barley harvested with a reaper and binder which is exposed to wet conditions in the shock, and possibly also to damage in the stack before thatching (Ref. 25).

In the farm drying of combine harvested grain, however, it is most important that the operator should check the moisture percentage of the grain. Barley grains with a high percentage of moisture are extremely sensitive to temperatures even a little above 100°F, but as they become drier they can withstand considerably higher temperatures without damage to the germination (Ref. 26). When barley comes out of the drier with 15-16 per cent. or more of moisture, it should immediately be re-dried because it would be dangerous to put such grain into sacks. Efficient drying not only preserves the grain from damage, but it also improves the germination and overcomes dormancy.

A new variety of six-row barley has been bred by the Cambridge University Plant Breeding Institute and marketed by the National Institute of Agricultural Botany. This new variety, named Prefect, is a winter barley obtained by hybridising Spratt-Archer with a six-row winter barley of German origin. Prefect has the typical procumbent habit of a winter barley, and the plants are small in the juvenile stage. The straw is tall and the lax ears are borne in pendulous fashion. Prefect was not bred as a feeding barley, but rather as a six-row type acceptable to maltsters and brewers; the grain is therefore bold, even in size and shape, and of a good colour, but the husk is somewhat thinner and the grain rather plumper than is normally associated with six-row barleys. It should be mentioned that the ear type is typical of the kind usually referred to by farmers as "four-row" barley (Ref. 27).

X. NEW WEED KILLING CHEMICALS.

More efficient and easily handled chemicals for weed killing are urgently needed in agriculture and the development of the use of growth substances for this purpose is of great interest and practical significance. It has been known for some years that growth substances used in comparatively low concentrations can have a depressing effect on plant growth, or can even kill plants. Experiments in recent years have shown that certain growth substances when applied to one part of a young plant, such as a leaf, can travel considerable distances in both up and down directions, and at certain concentrations can kill the plant (Ref. 28). It was also noted that certain plants, particularly grasses, growing in treated soil, were differentially affected, and the consequent deduction was that growth substances might be used as selective weed killers.

It has now been amply confirmed experimentally that certain growth substances are considerably more active than others as selective weed killers, and that the germination and early seedling growth of such weeds as corn buttercup, goosefoot, spurrey, charlock and poppy can be inhibited (Ref. 29). Furthermore, these growth substances can be used for weeds in cereal crops without affecting the crop, and the weeds can be killed at any stage from the seedling to flowering by spraying with solutions at the rate of one pound of active principle to the acre, or at two pounds to the acre applied dry in a filler of china clay. Another valuable attribute of these substances is that some of them persist in the soil for some time and are not readily leached out, but they ultimately lose their toxicity (Ref. 30).

Although the most active substances tested, such as sodium 4-chloro-2-methyl-phen-

oxyacetate, are not corrosive, they appear to be equally effective as weed killers when absorbed through the root or the leaf, but they are more effective with certain weeds than with others (Ref. 31). In America similar compounds have been used to kill field bindweed, and what is particularly significant, the subterranean parts of this weed were affected as well as the parts above ground (Ref. 32). It would appear that these growth substances have great potentialities as a means of chemical weed control and further field tests must be awaited with great interest. Experiments in this country have shown great promise for the destruction of perennial weeds in this manner (Ref. 31) and the phenoxyacetic acid derivatives are exceptional in that they alone are promising in this respect. There are indications that the spraying of grassland with 4-chloro-2-methyl-phenoxyacetic acid at concentrations which do not kill white clover, can destroy buttercup species, horsetails and partially suppress creeping thistle. Other weeds, such as docks, stinging nettles and bracken appear to be resistant at the concentrations which have affected or killed the species mentioned above.

G. D. H. BELL.

SCHOOL OF AGRICULTURE,
CAMBRIDGE.

References

1. Five Years of Wartime Farming. *Jour. Min. Agric.* 1944 : 51 : 372-81.

2. Staples Reconstruction Digests: What People Think. No. 6 Agriculture. *P. S. King and Staples, Ltd.*, London. 1944.

3. Advances in Grassland Husbandry and Fodder Production. First Symposium. Imp. Bur. of Pastures and Forage Crops, Aberystwyth. *Bull.* 32 : 1944.

4. The Provision of Animal Fodder in Tropical and Sub-tropical Countries, Pt. 1. Imp. Bur. of Pastures and Forage Crops, Aberystwyth. *Bull.* 31 : 1944.

5. Report of the Committee on Hill Sheep Farming in England and Wales. *Min. Agric. & Fish.* 1944 (Cmd 6498).

6. Report of the Committee on Hill Sheep Farming in Scotland. *Dept. Agric. Scotl.* 1944 (Cmd 6494).

7. Alternate Husbandry. *Imp. Agric. Bur.* Joint Publ. No. 6. 1944.

8. A Scientific Policy for British Agriculture. Rep. of Parliamentary and Scientific Committee.

9. FINDLAY, D. N., *et al.* Seeds Mixture Trials in Leicestershire. *Jour. Min. Agric.* 1945 : 51 : 439-43.

10. HANLEY, F. Sowing Seeds and Fertilizers Together. *Jour. Min. Agric.* 1944 : 50 : 493-6.

11. LEWIS, A. H. AND STRICKLAND, A. G. The Placement of Fertilizers. *Jour. Agric. Sci.* 1944 : 34 : 73-5.

12. PROBST, A. H. Influence of Fertilizer, Fertilizer Placement, Soil Moisture Content and Soil Type on the Emergence of Soya beans. *Jour. Amer. Soc. Agron.* 1944 : 36 : 111-19.

13. The Production and Use of Seed Potatoes. *Jour. Min. Agric.* 1945 : 51 : 443-6.

14. Dept. Agric. Scotl. *Miscell. Publ.* No. 3, Rev. Ed. 1944.

15. CLINCH, PHYLLIS, E M., *et al.* Notes on the Leaf Roll and Mosaic Diseases of Potatoes in Relation to Seed Potato Production. *Jour. Dept. Agric., Eire* 1944 : 41 : 263-76.

16. WILSON, A. R. AND BOYD, A. E. W. Potato Wastage in Clamps. *Jour. Min. Agric.* 1945 : 51 : 507-12.

17. CULBERTSON, J. O. Agronomic Considerations of Mechanised Sugar Beet Production. *Jour. Amer. Soc. Agron.* 1944 ; 36 : 558-65.

18. TOLMAN, BION AND STOUT, MYRON. Sheared Seed with Special Reference to Normal and Abnormal Germination. *Jour. Amer. Soc. Agron.* 1944 : 36 : 749-59.

19. STOUT, MYRON AND TOLMAN, BION. Field and Greenhouse Tests with Synthetic Growth-Substances Applied to Sugar Beet Seed and Plants. *Jour. Amer. Soc. Agron.* 1944 : 36 : 141-6.

20. THOMPSON, E. G. Mangold Trials 1936-38. *Jour. Nat. Inst. Agric. Bot.* 1944 : 5 : 28-44.

21. MORAN, T. The Quality for Bread-Making Purposes of Wheat Harvested in 1939. *Jour. Nat. Inst. Agric. Bot.* 1944 : 5 : 9-27.

22. ROBINSON, J. F. Oat Variety Trials 1936-44. *Pamphl.* Univ. Coll. North Wales, Bangor, *Jan.* 1945.

23. JONES, E. T. Aberystwyth-bred Varieties of Oats and Pure Line Selections of Hen Gymro Wheat. *Welsh Pl. Br. Sta. Leafl.* Series S., No. 5 : 1945.

24. WRIGHT, E. P. The Season's Barleys *Jour. Inst. Brew.* 1944 : 50 : 41-5.

25. NORMAN-SMITH, A. C., The Season's Barleys. *Jour. Inst. Brew.* 1944 : 50 : 286-90.

26. BISHOP, L. R. Memorandum on Barley Germination, Part 1. *Jour. Inst. Brew.* 1944 : 50 : 168-85.

27. Prefect Six Row Winter Barley. *Pamphl. Nat. Inst. Agric. Bot.*, August 1944.

28. MITCHELL, JOHN W. AND HAMNER, CHARLES L. Polyethylene Glycols as Carriers for Growth Regulating Substances. *Bot. Gaz.* 1944 : 105 : 474-83.

29. SLADE, R. E., *et al.* Plant Growth Substances as Selective Weed Killers. *Nature Lond.* No. 3939 : 1945 : 947-8.

30. NUTMAN, P. S., *et al.* Inhibition of Plant Growth by 2-4-dichlorophenoxyacetic acid and other Growth Substances. *Nature Lond.* 1945 : 155 : 498-500.

31. BLACKMAN, G. E., A Comparison of Certain Plant Growth Substances with other Selective Herbicides. *Nature Lond.* 1945 : 155 : 500-1.

32. HAMNER, CHARLES H. AND TUKEY, H. B. The Herbicidal Action of 2-4-dichlorophenoxyacetic acid and 2-4-5-trichlorophenoxyacetic acid on Bindweed. *Science* 1944 : 100 : 154-5.

DISEASES OF ANIMALS—PREVENTION AND TREATMENT

Bovine Mastitis. Much has been written on bovine mastitis : it is recognised as of major importance in agricultural economy. There is general agreement that the disease is associated with the presence of certain micro-organisms in the udder and, further, that these micro-organisms may be found in the milk without there being any evidence of mastitis. In this and most other countries one of the important micro-organisms is the *Streptoccocus agalactiae* which is found in the udders of many cows and is believed to be responsible for the majority of the outbreaks of mastitis. Most of the research work on mastitis and its control has been concerned with this streptococcus : it is found in association with both chronic and acute types of the disease. Good descriptions of these types are given by Roach (Ref. 1). The *chronic* disease may be present in milking cows over a period of years. The severity of the symptoms varies considerably : thus, the milk may be normal in appearance, except that at times the first few draws may consist of flakes or "curds." Symptoms may, however, become more definite following a variety of factors, such as cold draughts, a sharp drop in atmospheric temperature (*e.g.*, sudden frosts), a sudden change in diet or in milking routine etc. As a rule there is no systemic disturbance. It has been found that in some cows the affected quarters are difficult to dry off. Although it is usually held that chronic mastitis is of economic importance there is much evidence that some affected cows continue to give high milk yields. It is important to point out, however, that the chronically affected cow may develop acute mastitis when severe loss in milk yield may occur together with the possibility of a total loss of the affected quarter. The chronic disease is also of importance because of the risk of the spread of infection to healthy cattle. The *acute* type of mastitis due to this micro-organism is probably the most important of all affections of the udder : it is responsible for many of the blind and shrunken quarters and for much financial loss in terms of milk. The symptoms develop rapidly—the udder may appear quite normal in the evening but next morning the cow may be acutely affected : furthermore, it is not uncommon to find that the acute disease develops suddenly from the chronic form. This acute disease is almost exclusively confined to cows as opposed to heifers and may occur at any stage of lactation although acute attacks are comparatively rare in the later stages of pregnancy. There are several characteristic findings : although the hardness of the affected quarter varies from cow to cow and in some it remains comparatively soft, the skin of the udder over the affected quarter usually remains soft and mobile. As a rule there is little evidence of pain ; nor is there marked systemic disturbance in spite of severe local symptoms in the udder. Sometimes death occurs. The milk from an affected quarter varies in character : a constant feature, however, is the presence of white or cream-coloured flakes in a cloudy fluid which varies in colour from clear yellow to dark. It is found that if affected quarters are not treated within a month of the occurrence of symptoms the milking tissue is destroyed and the result is a blind quarter.

Some interesting and important observations on mastitis due to *Streptococcus agalactiae* were made by a group of workers in this country : the work was co-ordinated by the Agricultural Research Council (Ref. 2). This work showed the high incidence of the presence of this micro-organism in the herds which were under observation : the findings were " when cattle in the nine dairy herds were sampled at approximately weekly intervals over periods varying from 2½ to 6 months, the proportion of cows in these herds which, at one time or

another during the period of observation, yielded *Str. agalactiae* in the milk varied from 35.6 per cent. to 100 per cent. The proportion of cows that, at one time or another during the period of observation showed the presence of *Str. agalactiae* on the exterior of the teats varied from 45.7 per cent. to 100 per cent." It was also found that the micro-organism was recovered from the exterior of the teats without there being any infection of the interior of the udder or of the teat canal and that, especially when there were sores and abrasions on the teats, the micro-organism was often found in large numbers on the apparently healthy skin of the teats. *Str. agalactiae* was often found on the hands of milkers, sometimes long after milking had been carried out; it was also recovered from objects in the cowshed which milkers were likely to touch. From the results of such work it is easy to understand how infected cows are a great source of danger in the spread of the infection and how, if this source of infection could be eliminated, the disease could rapidly be brought under control. Attempts have been made to discover the cows in herds which are carrying the infection. The above report sums up the experiences of this method as follows :—" Under exceptionally favourable conditions, and with prompt elimination of all infected animals *Str. agalactiae* may sometimes be eradicated from a herd and its re-entry prevented for a period of several years; but failures and breakdowns are common, and a reduction in the frequency of the disease is more often attained than its elimination. Such methods are too slow, too uncertain, and too costly to offer a reasonable hope of freeing any large proportion of our dairy herds from *Str. agalactiae* infection."

It is somewhat difficult to give an agreed picture of the treatment of infected cows which may be adopted with good chances of success. Many publications have recently appeared on the subject: we are now awaiting the results of further work. It seems clear that drugs of the sulphonamide series are valuable whether given by mouth or by injection into the udder *via* the teats. For example, Roach (Ref. 3) has come to the conclusion that we are not yet in a position to promise more than a clinical response to such treatment. His view is that there must be a changed outlook so that we concentrate on prevention measures. In this connection in the above report (Ref. 2) it is suggested that if some antiseptic technique, combined with a modified milking procedure, could be devised, the risks of carrying infection from cow to cow would be greatly reduced; and the use of some chemotherapeutic agent which would give a high proportion of bacteriological as well as clinical cures might go far in eliminating infection instead of merely controlling it. Work on these lines is being pursued now. It is well known that the sulphonamide drugs appear to be successful in some herds and not in others. Roach and Hignett (Ref. 4) refer to this subject. They confirm the observations of many other workers that sulphanilamide treatments are often of value in effecting a clinical response but do not bring about a bacteriological cure of the udder. They also found that there is a difference in the response of different breeds: thus, Channel Island breeds usually respond well, while Ayrshires and Friesians respond less well, with Shorthorns occupying an intermediate position. They also draw attention to differences in strains of the infecting *Str. agalactiae* and in their response to sulphonamide drugs, although the different strains apparently behave similarly in the different herds. Such findings account in some measure for the success of a drug like sulphanilamide in a farm while it is of little value in another farm situated only a short distance away.

In addition to *Str. agalactiae* other micro-organisms are known to be associated with mastitis in cattle: thus, we have other types of streptococci, *Str. dysgalactiae*, *Str. uberis*, staphylococci and *Corynebacterium pyogenes* (found largely in outbreaks of summer mastitis). An important difference in the control of mastitis associated with these micro-organisms from that due to *Str. agalactiae* concerns their habitat. We have referred to the finding of *Str. agalactiae* in the udder and on the skin of the teats and udder and in various sites outside the body (see Ref. 2), and it is stated that " on the evidence as it stands, it is a

reasonable working hypothesis that the main reservoir of *Str. agalactiae* is in, or on the bovine udder, and that, if infection from this source could be eliminated, mastitis due to this particular organism might be effectively controlled." On the other hand Francis (Ref. 5) has shown the presence of various organisms in the tonsils and vaginae of cows but not *Str. agalactiae*, and in discussing the control of mastitis, Francis and Steward (Ref. 6) point out that the various streptococci (except *Str. agalactiae*), staphylococci and *C. pyogenes* are normal inhabitants of the bovine tonsil and vagina and thus it may be impossible completely to eliminate outbreaks of mastitis due to these micro-organisms. An interesting example of such an outbreak, in spite of the elimination of *Str. agalactiae* from a herd, is given by Neave, Sloan and Mattick (Ref. 7). A herd under control for some years was freed from *Str. agalactiae* infection; that is to say, none of these organisms had been recovered from the milk or teats of any of the cows, nor from the hands or throats of the milkers, since 1942. In 1943 a severe outbreak of mastitis occurred in the herd: 26 cows developed clinical symptoms characterised by lameness, swelling and hardness of the udder with altered milk in twelve, consisting of viscid clots in a coffee-coloured fluid. It was found that the infecting micro-organism was *Str. uberis*. It was known that this micro-organism was present in some of the animals in 1942, for in that year it had given rise to at least one clinical case of mastitis in the herd. It was concluded by these workers that this micro-organism, present in the udder of some of the cows had given rise to mastitis because of the action of the partial vacuum in the milking machine, which when tested, was found to be 19½ inches although the gauge was registering 15 inches. Reference has already been made in this journal (Ref. 8) to the milking machine as a factor in the causation of mastitis. The above authors suggest the fitting of two gauges for all milking machines and the certification of gauges.

The diagnosis of mastitis due to the various micro-organisms is not always easy, especially those types of the disease associated with the presence of different streptococci. Some success, however, has been reported from actual handling of the udder (Ref. 9).

From what has been written above it is obvious that, until the results of further work become available, the control of mastitis, especially that associated with *Str. agalactiae* should consist in the prevention of spread of the infection from cow to cow. Various measures can be adopted by farmers in effecting such a method of control. In this respect the following recommendations of Gould (Ref. 10) are noteworthy:—early detection of sub-clinical and clinical cases; prompt diagnosis of the type and the application of appropriate treatments; the cleansing and drying of teats with a hypochlorite solution *after* milking; the use of a sterile cloth for not more than ten cows; prompt treatment of chapped teats; and quiet handling of cows and milking at regular times.

Brucellosis (Contagious Abortion).

In this country efforts are being directed to the control of brucellosis by vaccination. While there are other methods for controlling the spread of this infectious disease, *e.g.*, the regular application of the agglutination (blood) test and the adoption of measures against the introduction of infection into herds free from the infection, it has become obvious that the setting up of an immunity by the use of a living vaccine is the method of choice in the great majority of herds. While vaccination has been practised in this country for a number of years it is only within quite recent times that special types of vaccine have been used. Experiences (especially in America) have shown that a high degree of immunity to natural infection follows the subcutaneous injection of a vaccine consisting of a suspension of *Br. abortus* organisms (the cause of brucellosis) which although living have been so altered in virulence that they are no longer capable of setting up infection in the injected animal. The vaccine now commonly used for this purpose in this and other countries is prepared from a

strain of *Br. abortus*, isolated by two American workers—the well-known Strain 19. It is only within the past few years that this vaccine has been used in this country. There is as yet little published information on the results of its use in this country: the results of observations in other countries, however, are gradually accumulating in the literature. An important paper was published in this country by Crawford (Ref. 11) in which experiences in America are discussed. Some points from this article may be found of interest to agriculturists and others in this country. It was between 1928 and 1933 that the first experiments were made in America with vaccine prepared from Strain 19 culture. Seventy calves, 4 to 8 months old, each received a dose of the vaccine and together with 73 non-vaccinated animals of similar ages were exposed to natural infection during their first pregnancy. The result was that of the 70 vaccinated calves (now heifers) 63 calved normally—only one aborted, while of the 73 non-vaccinated animals only 18 had normal calves—51 aborted. The Bureau of Animal Industry then began a five-year field trial in 260 herds heavily infected with brucellosis in which all the heifer calves were vaccinated when 4 to 8 months old: the infected adult cattle were allowed to remain in the herds in order to provide sources of infection. The results are described as follows:—" Of 8,182 pregnancies in cows vaccinated as calves during the first 4½ years of these trials 96.2 per cent were normal and 3.8 per cent. resulted in abortion. Of the latter, 58.7 per cent. were in cows negative to the blood test, which reduced the percentage of abortions due to Bang's disease to 1.6 per cent." The trials were carried on for a further two years at the end of which it was shown that the total incidence of abortion in the animals vaccinated as calves over all the period was 1.1 per cent. The calfhood method of vaccination for the control of abortion was officially approved in America in 1940: the various published results which have appeared in the literature from that time continue to give evidence that, in America, calfhood vaccination yields satisfactory results in the control of brucellosis. We have no published evidence of the results in this country: sufficient time has not yet elapsed since the introduction of calfhood vaccination to enable an estimate of the efficacy of the method to be made. By another year it should be possible to make some statement. It is important to note that Crawford points out that, while no apparent change has occurred in the virulence of the culture and that there is no evidence of the transference of infection due to the use of the vaccine, in order to maintain the vaccine in its satisfactory state the cultures from which it is produced must be properly handled. This is the task of the laboratories at which the vaccine is prepared.

Reference is also made to the vaccination of adult animals. The following quotations from Crawford's article sum up the position in America: "All evidence that has accrued from the vaccination of adult cattle indicates that the increased resistance resulting therefrom is equal, at least, to that produced in calves. Many practitioners use "whole-herd" vaccination as their sole method of controlling abortion and are satisfied with the results"; and "From experimental evidence, adult vaccination in the U.S. appears to have its chief application in early infection in pure-bred herds where valuable blood lines are involved. Where abortions have been occurring for a year or more this practice has not stopped the abortions immediately, although it undoubtedly prevented the spread of infection to many of the non-infected animals, especially the recently bred and non-bred heifers." While it is not advised that pregnant animals should be vaccinated (and this also applies in this country) Crawford says " it is believed that the number of pregnant cows in a herd that abort as the result of vaccination is no more and probably less than would contract the disease and abort if they were not vaccinated, and that a vaccinal abortion is much less undesirable than an abortion resulting from natural exposure." He points out that *Br. abortus*, strain 19, disappears from the genital tract and udder before the succeeding pregnancy, while the cow aborting from virulent Brucella is a potential spreader for an indefinite period. It has been shown that when abortion occurs in cows vaccinated during

pregnancy it is usually in animals vaccinated from the fifth month onwards and, further, that such abortions are more apt to occur in herds in which the animals are negative to the agglutination test. From this and other evidence there is little doubt that vaccination of adult cattle with strain 19 vaccine gives beneficial results in suitable herds. Further evidence is given by the observation of other workers in America. There is, for example, the view of Haring and Traum (Ref. 12) that " Adult vaccination need be practised only during one breeding season, since it can later be limited to calfhood vaccination unless a programme of revaccination be instituted." Further, the Sub-Committee on Brucellosis of the American Veterinary Medical Association (Ref. 15) wishes to emphasize that " adult vaccination should be considered only as an expedient to tide over difficult situations in particular herds, especially at times when it is essential to maintain production of meat and milk. According to such published and unpublished data as are available, the use of adult vaccination may bring about a decreased incidence of brucellosis in heavily infected problem herds. In such herds it should be used but once—and then should be followed by a programme of calfhood vaccination."

A question which is often asked is the duration of immunity following the injection of a dose of vaccine prepared from strain 19. There is, as yet, no definite answer so far as work in this country is concerned. We can, however, obtain some information on the subject from the literature. Crawford (Ref. 11) admits that the duration has not yet been definitely established in America. He says, however, that recent results indicate that where break-downs occur it is in the older animals which have been vaccinated some years. A significant quotation from his article is :—" the fact that in the field trials, where infected exposure animals were present, the immunity was not apparently decreased in six years, in comparison with the breaks in old vaccinated but negative herds, would indicate the necessity of revaccination at some definite period subsequent to the initial vaccination." Gilvray and Glover (Ref. 13) report from Canada observations on 17,500 calves in 1,475 herds vaccinated with vaccine prepared from strain 19 culture. It would appear from their results that vaccination of calves has proved of value in building up resistance against natural infection during the first pregnancy and to a lesser extent during subsequent pregnancies. They think that in order to provide further resistance against infection heifers should be re-vaccinated after their first period of gestation. Judging from the general principles of immunity it is to be expected that the resistance set up by a single dose of vaccine, even composed of living micro-organisms will tend to wane in time. Further stimulation is necessary to keep resistance at a certain level. This can be obtained either by exposure to natural infection which, if not sufficiently virulent to overcome the resistance engendered by the vaccine, will raise the resistance considerably ; or by the injection of a further dose of vaccine at the appropriate time. It will be obvious, therefore, that, generally speaking, whether revaccination is necessary depends to a large extent upon whether there is exposure of vaccinated animals to natural infection. In herds in which revaccination may be necessary experiments are required to fix the time when a second dose should be given.

An objection sometimes raised to the use of vaccine prepared from strain 19 is the production of agglutinins by the injected animals with the result that they react positively to the agglutination test. It has been shown and often recorded that one advantage in vaccinating calves is that a large proportion of them become negative or almost negative reactors by the time they have reached breeding age. A statement on this subject is found in Ref. 12 to the effect that 60 per cent. of animals vaccinated up to 16 months of age were negative after two years and after five years the incidence had risen to between 90 and 100 per cent. Some of the American workers, however, take a view similar to that sometimes expressed in this country—*viz.* " the average herd owner is interested primarily in securing a normal calf crop (not blood negative tests) : the persistence of blood titre is secondary

in interest." While this view applies to a large proportion of the breeders of livestock in this country, there are others whose interests lie in having cattle which do not react to the agglutination test. It is obvious from the present state of our knowledge that using vaccine prepared from strain 19, must, in their case, be confined to calfhood vaccination, when it is to be expected that as the vaccinated calves reach maturity they will, largely, have ceased to be positive reactors: the vaccination of heifers approaching maturity will mean that probably for a considerable time, often some years, positive reactors to the agglutination test will be found.

Crawford (Ref. 11) refers to another method of vaccination. The usual method is to inject the vaccine subcutaneously (*i.e. under* the skin): the new method referred to is the injection of the vaccine intradermally (*i.e., into* the skin). While more work is required on this method it is claimed that the results obtained up to date have been satisfactory. The advantages of such a method, in addition to a smaller dose of the vaccine being required, are said to be that the agglutination titre which is found to follow the injection of vaccine prepared from strain 19 disappears in young animals more quickly following intradermal than subcutaneous injection (although it does not seem to hold for older animals) and that there is no systemic disturbance with temporary lowering of milk yield in injected lactating animals.

Following the vaccinating of adult cattle by the subcutaneous method as now practised there occurs in some a systemic disturbance or reaction: in some animals it may be more severe than in others and in lactating cattle there is sometimes a drop in milk yield. We have now some precise information on this subject for Holman and McDiarmid (Ref. 14) carried out some observations. They found that the daily milk yields of six cows inoculated with strain 19 vaccine and eight cows with two doses of 45/20 (at an interval of three weeks) compared with 15 control cows showed an average loss in milk following vaccination of 24 lb. per cow with an individual loss varying from 0.3 to 80 lb. They found, further, that the loss was most pronounced from two to four days following vaccination and that it was negligible after nine days.

In the transmission of infection the infected cow is the important subject. It is well known that the aborted foetus, afterbirth and discharges are highly infective and that infected cows and heifers are capable of excreting infection so long as discharges persist: further, it is well known that infected cows and heifers excrete the causal micro-organisms at parturition even although the calf is full term. Opinions differ on the part played by the bull in spreading infection. Some recent information comes from Denmark (Ref. 15) from which it would appear that the bull may play but little part. The experiments included the use of four bulls which were known to be excreting *Br. abortus* in their semen: they served 27 clean heifers of which 19 calved normally, the remaining eight failed to conceive—none aborted nor were any found to be infected. In a second experiment three bulls were used to serve 22 normal heifers immediately after serving cows which had recently aborted and were discharging *Br. abortus.* None of the heifers aborted: 14 calved normally and eight failed to conceive. It is concluded from these observations that "these experiments further invalidate the view that copulation is of significance in the spread of infectious abortion in cattle."

Diseases of Poultry As the general food position for livestock improves there will be an increase in the numbers of poultry kept throughout the country: there are already signs of this increase. It is becoming more generally held that poultry should be one of the activities of general farming; there is much to be said for this view. With the increase in poultry it is certain that disease will become more prevalent unless control measures are adopted. It is true that for some diseases we have still to discover satisfactory methods of prevention and treatment: but results of research work are gradually being applied and are proving

satisfactory in the field. Recently, some quite important pieces of research work have been carried out : an account of some of them should prove of interest to agriculturists. This work has included the study of new methods of controlling some of the well-known diseases as well as investigation into apparently new diseases which have made their appearance in this country.

Coccidiosis. Coccidiosis is widespread and in seasons suitable for the development of the causal agent outside the body it is probably the greatest single cause of loss among growing young stock. It is known that several forms of the disease exist, caused by different strains of coccidia : probably the strain which infects young stock is the most important from an economic point of view. It is the *Eimeria tenella* and causes acute inflammation of the chick's intestine, especially the caeca : marked haemorrhage of the caeca is a feature of the infection. The life-history of the parasite has been worked out : it is known, for example, that part of the cycle has to be spent outside the body when important changes occur rendering the parasite infective to chicks. The time required for these changes to occur depends largely on climatic conditions, *e.g.*, temperature, moisture, etc., but even under the most favourable conditions they are not completed for at least 36 hours after the parasite has left the fowl's body in the droppings. Coccidia can, however, survive outside the body for very long periods and can quickly undergo the necessary changes to render them infective for fowls when the suitable conditions arise. Advantage was taken of this period which the coccidia have to spend outside the body in controlling infection. The method consisted in preventing access to the parasite in its infective stage either by moving young chicks to new ground every day or so or by keeping them on wire, so that they had no access to droppings containing the parasite, or by cleaning out the premises regularly every day or every other day and so removing the parasites voided by the chicks before they attained the infective stage of development. It has now been shown that the disease can be controlled by the use of one of the drugs of the sulphonamide series, *viz.*, sulphamethazine. In 1942 Horton-Smith and Taylor (Ref. 17) showed that pure sulphamethazine given in the food at the rate of 1—2 per cent. prevented deaths from coccidiosis in experimentally infected chicks. They found, however, that the good results were not obtained when treatment was delayed until 72 - 96 hours after the infection occurred. In the same series of experiments it was shown that equally good results followed the use of a saturated solution of the drug. In 1943 (Ref. 18), the same authors found that by substituting for drinking water a saturated solution of sulphamethazine, at the time of the first appearance of symptoms of the disease in experimentally infected chicks, the mortality was reduced by 45 per cent. Results of further observations have just been reported (Ref. 19). The same workers have found that the " administration of sulphamethazine in the drinking water was effective in the control of induced epidemics of caecal coccidiosis. In three experiments the rate of mortality among treated chicks was reduced by 50 –78 per cent. of that among the untreated, control chicks." They also found, and this is of great significance, that there was developed a strong immunity to coccidiosis in chicks which as a result of sulphamethazine treatment had survived a previous outbreak. This means that with sulphamethazine treatment not only can the spread of caecal coccidiosis be prevented during an outbreak but chicks treated during an outbreak fail to develop the disease when exposed at a later date. Sulphamethazine has also been used in America (Ref. 20) when it was found that, when treatment in the form of substitution of a saturated solution of the drug for drinking water was commenced 98 hours after the first disease symptoms were observed, although some symptoms continued for 5—6 days, the chicks thereafter showed greatly increased vigour and grew well.

Six-day Chick Disease. In 1944 attention was drawn from several sources to the high death-rate in young chicks which commenced at about the sixth day after hatching and

ceased a few days later. Examinations carried out at various laboratories failed to establish the presence of an infection. Speculations as to the cause varied but eventually the underlying cause was narrowed down to something nutritional in character. Experiments and field observations carried out by Temperton and Bythell (Ref. 21) led these workers to the conclusion that the cause was a deficiency of available energy in the chick mashes being used. They held the view that there were several contributory factors which were collectively responsible, *e.g.*, lack of whole grains and maize products, a deterioration in the composition of the Nitrogen-free extractives of millers' offals and the inferior quality of other cereal products which were permitted to be sold for poultry feeding.

A different view was expressed by Taylor (Ref. 22): he attributed the deaths to the inclusion of extracted palm kernel meals in excess of 10 per cent. by weight. He suggested that the solvent used in the extraction process left some toxic residue in the meal which caused the death of the chicks. This view could not be upheld by the above workers (Ref. 21) : they did not find any toxicity in the samples of meal which they examined and which had been associated with the death of chicks. They do state however that a large quantity of palm kernel residues is undesirable in chick mashes for they are unpalatable and provide inadequate metabolisable energy. Wilson (Ref. 23) also failed to show that such products were toxic for young chicks. Observations carried out by Asplin, Dobson, Gordon and Blaxland (Ref. 24) led them to recommend the supplementing of the chick mashes available to poultry keepers with grain : they reported good results from such feeding. They also state, however, that "it seems likely that a fall in temperature which occurs during the autumn nights in certain types of brooders is sufficient to reduce the viability of chicks and to stimulate the onset of losses which would not otherwise have occurred." Although attention was drawn to this disease only in 1944, McGaughey (Ref. 25) records its presence in Cheshire in 1932-1936. He carried out some experimental work and was able to reproduce the condition by feeding intestinal contents of diseased chicks to healthy day-old chicks and by placing healthy chicks in contact with contaminated or diseased chicks. He also succeeded in isolating a strain of the micro-organism, *Clostridium welchii*, from the intestine of diseased chicks : by feeding this strain he was able to reproduce the disease. He expressed the view that dietetic errors may give rise to an alteration in the bacterial flora of the intestine with fatal results. Taking all the evidence into account it would appear that the type of food contained in the mashes fed to young chicks during some of the war years was probably responsible in that, although its composition from an analytical point of view appeared satisfactory, it was deficient in available energy. The result was that in some instances chicks were unable to survive even when kept under ideal brooding conditions : when exposed to bad brooding conditions which could be tolerated by chicks fed adequate diets as prevailed before the war, chicks fed on war-time mashes were unable to survive. As the food position improves and maize and whole grain again become available for chicks, six-day disease is likely to disappear. It is well, however, to be aware of its occurrence under the above conditions of feeding and management.

Salmonella Infections. Poultry are apparently highly susceptible to infection with micro-organisms of the Salmonella group. The most commonly found diseases caused by such micro-organisms are pullorum disease (bacillary white diarrhoea) caused by *S. pullorum* and fowl typhoid, caused by *S. gallinarum*. These diseases are well known and satisfactory methods of control are being practised. As a matter of interest concerning the spread of pullorum disease it has been shown by a Canadian worker (Ref. 26) that flies can carry the infective agent on their wings and feet and that flies fed on material containing *S. pullorum* excrete the micro-organism for 5 days from their intestinal tract. It has also been known for some years that other members of the Salmonella group were capable of setting up disease in young birds, both chicks and ducklings. An account of losses in ducklings

caused by the micro-organisms *S. enteritidis* and *S. typhi-murium*, recorded by Gordon and Garside (Ref. 27) shows the damage which can be caused by them. They discuss an outbreak in which 57,000 ducklings were involved : losses at the rate of 1,000 per day occurred and in all some 30 per cent. of the ducklings died. Infection with these micro-organisms differs from that caused by *S. pullorum* in that there is no good evidence that the infection is passed through the egg from adult to chick. They differ, further, because, while the agglutination test (tube or rapid slide methods) is valuable in diagnosing carriers of *S. pullorum* infection among adult fowls and is thus used in the control of pullorum disease, this test cannot be relied upon to detect fowls or ducks infected with the above-named members of the Salmonella group. It has been recently shown that still other members of the group give rise to disease and losses in chicks. Investigations in America and in this country have shown that many members of the group can be recovered from diseased chicks and that adult fowls also harbour them, although presenting no symptoms of disease. Thus, Wilson (Ref. 23) records that infection of young chicks with the micro-organism *S. thompson* occurs quite frequently : he also points out that rats and mice are commonly found to carry salmonella infection and recommends that precautions should be taken to prevent the access of such vermin to feeding stuffs. Again, Gordon (Ref. 28) refers to the increase in infection in this country due to new strains of salmonella. He points out that these micro-organisms are found in adult fowls and are excreted in the droppings. Contamination of the shells of eggs laid by such fowls is therefore quite common and thus incubators may become infected and give rise to outbreaks among young chicks hatched in them. Until the results of further research work are available the control of these salmonella infections must be concerned with hygiene of incubators, preventing contamination of foodstuffs from likely sources of infection and the rearing of young chicks under conditions whereby they will not have contact with adult stock.

Pullet Disease. There has been described in America during the past few years a new disease, mainly among pullets, which has been given different names by the various observers. The occurrence of a similar disease in this country has been observed by Gordon and Blaxland (Ref. 29). They record 20 outbreaks during 1943 and 1944. The condition affects mostly fowls in lay or those just commencing production, although a few affected cockerels have apparently been observed. The mortality is usually low but the disease is serious in that there is a very marked drop in egg yield ; production may entirely cease. The outstanding symptoms are " blue comb," distended crop and the decrease in egg production. The characteristic *post-mortem* findings are nephritis (inflammation of the kidneys), visceral gout (the deposition of grey coloured urates on the internal organs) and degeneration of the ovary. As yet we have no real clue as to the cause : it has not been found possible to transmit the disease under experimental conditions and no infective agent has been recovered. There is some suggestion that the origin of the condition may be nutritional.

Fowl Paralysis. It has now been fairly conclusively shown that the disease in poultry popularly termed fowl paralysis is an infectious condition and that the commonly found lesions, *e.g.*, enlargement of nerves and the presence of lymphomatous tumours in different parts of the body, represent a chronic stage of the infection (Ref. 30). The disease can be reproduced by the use of these lesions in healthy fowls : the infective agent is contained in the lesions and it is found also in the droppings of some of the infected fowls. In the young chick the disease can assume an acute form with lesions especially in the liver and heart : it can cause the deaths of young chicks but some recover and later in life may develop the chronic form of the disease. The transmission of the condition is probably through the egg and by contact of healthy young chicks with infected adult stock. As yet we have found no satisfactory method of controlling the disease except by adopting hygienic measures, breeding from stock without a history of the disease and by rearing young stock apart from

adult fowls. Recently some interesting observations were made by Asplin (Ref. 31) who showed that the infective agent is sensitive to drugs of the sulphonamide series. Working with young chicks he infected them and then tried the effect of a number of these drugs. He had most success with sulphadiazole: of 138 chicks inoculated with 18 strains of the infective agent and treated with sulphadiazole in the food none developed lesions of the disease, while of 117 infected, untreated, controls, 101 showed gross lesions. Other drugs of the sulphonamide group did not yield such successful results. He places the drugs in the following order according to their effects in preventing the disease in young chicks:—sulphadiazole, sulphamethazine, sulphathiazole, sulphapyridine and sulphaguanadine. Sulphanilamide is too toxic for young chicks to be effective. We are now awaiting the results of further experiments in order to determine whether any of these drugs has a place in the control of fowl paralysis under field conditions.

The Control of Internal Parasites. We have already written on the beneficial effects of some of the drugs now used in controlling internal parasites, especially the recently introduced phenothiazine which is now largely used in sheep. Several points of interest have been recorded during the past year. Experiments in America and in other parts of the world have been carried out with a view to ascertaining whether good results would follow if sheep were allowed access to phenothiazine over a period, so preventing the actual handling of the animals for treatment. The phenothiazine is mixed with salt and fed to the sheep. Britton, Miller and Cameron (Ref. 32) give an account of some experiments carried out in continuation of those begun in 1942. They had found that when using copper-sulphate-nicotine-sulphate mixture about 12—15 per cent. of the treated lambs failed to fatten satisfactorily: they suffered from gastro-enteritis, caused apparently by the helminths, Ostertagia and Trichostrongyles. They tried the use of a mixture of phenothiazine and salt (1 to 15 parts) to which the lambs had constant access. Two groups of lambs were used, 198 in each group; one group had access to the mixture, the other group was untreated. The result was that the treated group increased in average weight by 37.7 lb. against an increase of 24.6 lb. in the untreated lambs. All the rest of the flock, which consisted of 5,200 lambs, was given access to the mixture: only 32 lambs died. In another experiment 3,000 lambs had access to the mixture for 6 weeks: 100 were kept as controls. After 3 weeks 1,200 of the treated lambs and 10 controls were marketed as fat lambs. By the end of the trial, 3 controls had died of parasitism and the remainder scoured badly while only 31 of the 3,000 treated lambs had died from all causes. Britton and Miller (Ref. 33) record the results of tests with various medicaments and conclude that, taking all factors into consideration, phenothiazine is significantly superior to any of the other treatments especially when there is free access to a mixture with salt (1 in 10). They say it most nearly approaches the ideal anthelmintic in being non-toxic, easy to administer, cheap and effective. Some further results are recorded by Peterson *et al* (Ref. 34) from which it is concluded that phenothiazine-salt mixture (1 in 14), available to sheep throughout the grazing season, protected ewes and lambs against clinical parasitism when the sheep were relatively free from internal parasites at the beginning of the trial and were not allowed access to pastures recently contaminated by parasitised, untreated sheep. They found, however, that the same mixture was not able to protect sheep when they were placed in pasture heavily contaminated with viable parasitic ova. From this and other evidence it would appear that there is some value in phenothiazine-salt mixtures provided that all the sheep have access to them and that the pastures are not already heavily contaminated.

In connection with the parasitic infestation of sheep there may be a general feeling that hill sheep do not suffer to any marked extent. It has been shown, however, by the observations of Morgan and Sloan (Ref. 35) that hill sheep may be quite heavily infested. These workers studied sheep in the South of Scotland and found that nearly 4 per cent. of the 719

sheep and lambs which they examined were in poor condition and had high worm egg-counts. They point out that there must be certain areas on the hills where concentration of sheep faeces produce enough infective larvae to allow of the building up of heavy infestations in animals continually grazing there. This work indicates that when the intensity of the stocking is as low as one sheep to 4 or 5 acres it cannot be assumed that helminths are of little or no importance for, as the authors say " concentrations of sheep on small areas in the hills are frequently higher than obtain in lowland sheep, and when allied with severe weather conditions and low nutrition, helminthiasis may occur in a considerable proportion of animals, particularly in the lambs and hoggs."

The use of phenothiazine in cattle is also receiving attention. An interesting account of a trial by Britton (Ref. 36) is worth recording here. He treated three primary outbreaks of parasitic gastritis in calves, *i.e.* outbreaks which came on gradually in young animals on fattening pastures. He used phenothiazine in doses of 12 grams for calves and 30 grams for yearlings. He also treated five outbreaks of secondary parasitic gastritis, *i.e.* outbreaks which were complicated with malnutrition. All responded well. His third group consisted of young cattle in which parasitic gastritis and heavy lungworm infestation were both present. He treated 100 such animals and left 20 as controls. The result was that of the 20 controls only 5 survived while of the 100 treated animals only four failed to recover and in each case there was a secondary pneumonia due to lungworm infestation. It was found that the use of a phenothiazine-salt mixture was not so successful in cattle as in sheep: this was probably due to the consumption of inadequate amounts of the mixture and hence not a sufficient quantity of phenothiazine.

Gibson (Ref. 37) carried out some experiments in horses in which he gave small daily doses of phenothiazine (1 gram) for 30 days. He found that although this treatment did not result in the elimination of strongylid worms from the horses, it did, however, produce a fall in the egg count to a very low level or to zero: this was referable to the inhibition of egg production. He showed that this inhibition persisted for as long as 35 days after the treatment was stopped. An important finding also was that, during the period when phenothiazine was being administered, the eggs passed in the faeces were prevented from developing into the third stage larvae. This finding can have a considerable bearing on the prevention of contamination of pastures.

Bovine Tuberculosis. The position of bovine tuberculosis in this country is that attempts are being made to clear herds by the use of the tuberculin test. We have already dealt in former numbers of this *Journal* with some of the difficulties of the interpretation of the test. Several interesting and important points on bovine tuberculosis have been recently recorded. There is now accumulating evidence that bovine tuberculosis in the adult human being may be more common than has been appreciated. It has always been recognised that tuberculosis of the bovine type was the cause of a considerable amount of disease in children and young people, and that the infection occurred in lymphatic glands (usually cervical and abdominal) and in bones and joints. Tuberculosis of the lungs (pulmonary tuberculosis) was usually considered to be associated with the human type of the tubercle bacillus. Recent investigations indicate that pulmonary tuberculosis may quite often be due to infection with the bovine type of the bacillus. Stanley Griffith and Munro (Ref. 38) investigated 2,769 cases of pulmonary tuberculosis in Scotland and 3,592 in England. They found that the proportion of bovine infections was higher in Scotland than in England. The highest incidence, 25.8 per cent. was found in the Orkney Islands; the next highest was in rural districts of north-east Scotland with a percentage of 9.1; in the rest of Scotland the incidence was 5.2 per cent. In England the highest incidence was in the North and Midlands with a percentage of 2: in the South of England the incidence was only 0.6 per cent. From their examination they were of opinion that, in many cases, the digestive tract was the

channel of entry ; and there is some evidence that infection from cattle by inhalation occurred in some further cases ; and there were suggestions that the bovine infection had spread in some still further cases from man to man. Another record on this subject is given by Cutbill and Lynn (Ref. 39) who have made examinations of sputum from cases of pulmonary tuberculosis since 1934. Of the 2,101 positive cases, they found bovine tubercle bacilli in 48 or 2.28 per cent. They suggest from their examination of records etc., that the infection originated from tuberculous milk in 16 cases, that direct contact with cattle probably accounted for a further 6, while they were unable to find a definite origin in 19 cases. There was also some evidence that in three families, while the original infection was acquired from cattle, subsequent infection in each family spread from the originally infected members to others. Such information as that contained in these two publications adds to our knowledge of the damage to human beings that can arise from tuberculosis in cattle : in the adoption of measures to control tuberculosis in cattle the fact that transmission to human beings can take place even in the adult state must be remembered as well as the possible spread of bovine tuberculosis among human beings from an original infection from cattle. There is also the other side of the picture. Infected human beings may infect healthy cattle. There is some evidence that the human type tubercle bacilli derived from human sources may cause a fleeting infection in cattle, which, however, may be of sufficient importance to cause difficulties in the interpretation of tuberculin tests. There was published last year a paper in which some evidence is produced that human beings infected with bovine tuberculosis might pass the infection to cattle (Ref. 40). It is reported that three herds consecutively owned by one farmer in two and a half years were found infected with tuberculosis. In his first herd all the 24 cows became positive reactors to the tuberculin test within 100 days. The tests were carried out because milk from the herd had caused tuberculosis in another farmer's calves. The 25 cows were replaced on the same farm, after suitable disinfection, by 12 negatively reacting cows : within 5 months each became a positive reactor. A similar experience occurred with the third replacements. *Post-mortem* examinations showed that the animals had been recently infected. It was found that the farmer himself was tuberculous and bovine tubercle bacilli were isolated from his sputum. The same author quotes another herd where there was some suggestion that the farmer had transmitted infection to his herd. Examples such as these show how herds may " break down," and such circumstances are to be borne in mind in dealing with herds in which positive reactors to the tuberculin test suddenly appear.

In the transmission of tuberculosis from cow to cow and from herd to herd there is little doubt that the direct contact of infected with healthy cattle is by far the commonest method. In the above section another method is mentioned. That there are still other ways is shown by recently published papers. Thus, McFarlane, Garside, Watts and Stamp (Ref. 41) describe the transmission of tuberculosis to a clean herd of cows by irrigation of the udders, presumably following the irrigation of the udder of a cow suffering from tuberculous mastitis. Further, Berger (Ref. 42) shows the high incidence of tuberculous infection in vaginal discharges (he found 12 infected discharges in 128 cows which he was examining for infertility). His observations confirm those of Steward (Ref. 43) who, in a series of 78 cases in which samples of uterine discharge were examined, found 24 to be positive for tubercle bacilli. Such findings emphasize the importance of looking for other means of the spread of tuberculosis in cattle than by direct contact between infected with non-infected stock.

In the testing of tuberculin for use in the tuberculin testing of cattle it is usual to make tests on guinea pigs which have been sensitised by being artificially infected with tuberculosis : tests are also made on cattle to determine the potency and degree of specificity of the tuberculin. It is known that various micro-organisms of the acid-fast group, *i.e.* the group

which includes the different types of tubercle bacilli, give rise to sensitivities of different degrees to tuberculins used in cattle testing : this is one of the facts that cause difficulty in the interpretation of the tuberculin test in cattle. The results of some observations on guinea pigs carried out in this country have already been referred to in these writings. A further contribution to our knowledge on the subject comes from work carried out in South Africa by Canham (Ref. 44). Following results on calves he concludes as follows :—" To sum up, one would say that the tuberculin reactions given by the calves sensitised by *M. phlei* and *M. butyricum* (these are non-pathogenic micro-organisms of the acid-fast group) would be negative if judged solely on clinical appearance. If judged by clinical appearance plus measurements they would be regarded as suspicious, while finally, if measurements alone were the criterion, they would be classed as positive." The result of work on such lines is assisting in the understanding of tuberculin reactions in cattle in this country.

Poisoning in Livestock. In last year's volume of this Journal we discussed some of the reported poisonings of livestock, referring to actual instances in the current literature. During the past year further observations have been recorded and the subject is again discussed.

Nicotine Poisoning in Lambs. Last year reference was made to the poisoning of cattle following dressing with nicotine and lime in the control of warble infestation. The deaths of 18 three-month-old lambs are recorded by Crawshaw (Ref. 45) as a result of overdosing with nicotine-sulphate solution. In addition to the lambs which died others were sick but recovered. They showed much depression and obvious discomfort : there was no diarrhoea. Post-mortem examination revealed much inflammation in the oesophageal groove and the abomasum (fourth or true stomach) as well as in the first part of the small intestine : the kidneys also showed some evidence of inflammation. It was concluded from various examinations that the toxic dose of nicotine-sulphate for lambs of this class (they had an average weight of 37.2 lb.) lies between 3.2 and 4.8 grains, *i.e.* between 0.64 and 0.96 grains of actual nicotine. The author also records that 16 grains of nicotine-sulphate, *i.e.* 3.2 grains of actual nicotine, was the dose required to produce toxic symptoms in bulls and heifers of 12-18 months of age.

Poisoning of cattle by Dog's Mercury (Mercurialis annua. L). Barron (Ref. 46) describes poisoning by Dog's Mercury in Shorthorn cows and heifers. They were moved to a rough pasture which had not been grazed by cattle for many years. Within a week one, and soon afterwards another, died. Both cows and heifers showed symptoms which consisted of lassitude, lying down a lot and reluctance to move, frequent urination (urine varied from pale pink to dark coffee in colour) with marked anaemia as shown by the white appearance of the mouth, gums and eye membranes. Some showed evidence of jaundice. A *post-mortem* examination showed that the entire carcase was deep yellow in colour (jaundiced) and the bladder was filled with coffee-coloured urine. There were no ticks present. A heavy mat of the plant dog's mercury was found : it had been heavily grazed.

Zinc Phosphide Poisoning. Zinc phosphide is now used on an extensive scale as a poison for rats, etc. : it is also toxic to livestock and deaths, especially of poultry, have been reported from farms on which the poison was being used. Hare and Orr (Ref. 47) recorded three instances in different parts of the country. Death apparently takes place rapidly : the fowls are usually found dead.

Blaxland and Gordon (Ref. 48) record thirteen instances which occurred in different parts of the country. They carried out some experiments to determine the toxic dose for poultry and to study the symptoms and *post-mortem* lesions. They came to the conclusion that the toxic dose was approximately 1/5 grain per lb. body weight. Deaths occurred within 3-16 hours after the poison was given—the actual time depending on the amount of

food already present in the crop. In nearly every case, on *post-mortem* examination, there was an unpleasant odour from the crop and gizzard: this was due to the presence of the gas phosphine, which is liberated from zinc phosphide. These authors provide a valuable account of the essential differences between the characteristic features of poisoning in fowls by the four most common causes, *i.e.* phosphorus, arsenic, zinc phosphide and cacao residues. In phosphorus poisoning the carcase and visceral organs are somewhat jaundiced and the liver is very fatty (often yellow): there is also the characteristic odour of wet matches and visible fumes can be seen when the gizzard is opened. In poisoning by arsenic there is intense inflammation in the gizzard with separation of the horny layer from the underlying tissues by a gelatinous substance: there is no characteristic odour. The odour of phosphine is characteristic of poisoning by zinc phosphide. In poisoning by cacao residues the crop and gizzard usually contain dark chocolate-coloured material and there is an odour of chocolate.

Zinc phosphide poisoning has also been recorded in a colt by Ingram (Ref. 49). The poison had apparently been laid on the pasture where the pony was grazing: it died in a few hours after symptoms were observed. The amount consumed was about 7 grains.

Charlock poisoning of lambs. While charlock is commonly found in many parts of the country and livestock often have access to it, it appears that, under some conditions, it may act as a poison. Gallie and Paterson (Ref. 50) describe apparent poisoning in wedder lambs. Two lots of the lambs were folded at extreme ends of a rape field: receiving a supplementary feed of crushed oats. In one batch (180 lambs) deaths began on the fourth day and continued until the lambs were removed on the seventh day (one died the following day). No trouble was experienced in the other batch of lambs. Although charlock was present at both ends of the field, it was much more abundant at the end where the deaths occurred: the charlock was well podded with fully formed seeds and was so abundant that it was impossible for the lambs to get the rape without eating the charlock. *Post-mortem* examination showed inflammation of the stomach and intestine. The charlock was pulled out and the lambs were put back on the pasture: no further trouble occurred. It is said that charlock is toxic when the seeds have formed, the principal toxin being mustard oil. It may be asked why charlock poisoning is not more common in sheep: the answer is probably that they do not normally eat the plant

Mushroom poisoning in cattle. From America (Ref. 51) comes a report of alleged poisoning by mushrooms It occurred in a herd of cattle grazing on pasture on which large growths of white mushroom (*Amanita verna*) were present. The pasture was bare and the animals had eaten the mushrooms. Few deaths occurred but illness was common, the most striking symptom being the great unwillingness to defaecate, which was done with considerable pain The faeces accumulated around the buttocks. There was marked loss of weight *Post-mortem* examination showed much inflammation throughout the alimentary tract. Experiments were carried out on rabbits when the symptoms and lesions were reproduced. Attempts to cause poisoning in a calf by feeding the mushroom failed but it is thought that the amount fed was too small.

Lead poisoning. Attention was drawn in last year's volume of this journal to lead poisoning in calves. Some further notes on the subject have been recorded. King, Barrick, Hoefer and Doyle (Ref. 52) found illness in calves, 4 to 8 weeks old, which had been licking a fence which had been painted three years previously. The calves ceased to suck, showed muscular tremors, were partially or completely blind, staggered about and finally showed convulsions and died. The constant *post-mortem* finding was inflammation of the kidneys The trouble ceased when measures were taken to prevent access to the painted fence. Analysis of the liver of the affected calves showed lead to the amount of 46.8 mg./kilo: in normal calves the amount was 0.93 mg./kilo. Experiments in which lead

acetate and lead carbonate were fed to calves in milk gave rise to convulsions and death.

Poisoning of cows by lead in salvaged soya bean meal is reported by Watson and Adams (Ref. 53). Two farms were involved. On one farm three cows went off their feed, were dull and showed signs of abdominal pain. From an analysis of the soya-bean meal it was calculated that each animal would receive about 1/10 ounce of lead from the meal. On the other farm about twice the amount of meal was fed. Here the symptoms in the affected cows were more acute than on the first farm and consisted of acute abdominal pain, great excitement and pressing the head against the wall. One cow continued to show symptoms for three weeks after the feeding of the meal was stopped. Some of the animals never showed marked symptoms: in some, the only symptom appeared to be hypersensitiveness of the udder when milked.

Johne's Disease. In some districts Johne's Disease is of considerable economic importance. The causal micro-organisms are found in the intestine and are expelled in the faeces. It is easily understood, therefore, how ponds, streams, pastures, etc. become contaminated. The survival of these micro-organisms outside the body has been the subject of investigations carried out by Lovell, Levi and Francis (Ref. 54) and their findings will be of much value in the adoption of methods for the control of the disease. The authors carried out three series of experiments. In the first series they used artificial cultures of the micro-organism added to muddy water, tap water, pond water and saline solution, each of which had been sterilised before the experiment was begun: the various emulsions so formed were kept in a cupboard at ordinary temperature. It was found that, under these conditions, the micro-organism was still alive after nine months. In the next lot of experiments, scrapings from the intestine of infected cattle were used (the scrapings contained the micro-organism). They were added to unsterilised river water and ditch water and the mixtures were kept in the open air. In one test the infective micro-organisms were found alive 113 days later, although the water had been frozen during the early part of the experiment. In another test carried out on the same lines the micro-organisms were recovered after 163 days. The third series of experiments consisted in study of the survival of the micro-organism in naturally infected faeces. The faeces were kept in containers exposed to the full effects of weather, rain and sunshine; thus on occasions they were fluid, frozen or dried up by the sun. Kept under these conditions it was found that the micro-organisms could survive for as long as 246 days. It was also shown that they survived longer under moist than under dry conditions. In discussing these results, the authors say "our observations, however, give support to certain suggestions made in the control of Johne's disease. It is not unreasonable, considering the longevity of the organism, to allow infective pasture to be regarded as unsafe for at least one year. It is also a sound policy to encourage such methods of procedure as the breaking up of manure on infected pasture land, the disposal of manure from standings to cultivated land and the drainage or fencing of ponds."

T. DALLING.

VETERINARY LABORATORY,
NEW HAW,
WEYBRIDGE, SURREY.

References

1. ROACH, R. W. Mastitis and the Practitioner. *Vet. Rec.* 1944, **56**, 13-16 and 25-29.

2. ——————. Modes of spread of Streptococcus agalactiae infection in dairy herds: a report on co-ordinated observations organised by the Agricultural Research Council of the United Kingdom. Imperial Bureau of Animal Health, Weybridge, Surrey. *Review Series*, No. 2.

3. ROACH, R. W. The use of sulphathiazole *per os* and of sulphanilamide E.O.S., sulphanilamide L.S.F., sulphanilamide emulsion, acriflavine emulsion, proflavine sulphate solution, tyrothricin and novoxil, by udder infusion, in the treatment of clinical Streptococcus agalactiae mastitis. *Vet. Rec.* 1944, **56**, 457-458.

4. ROACH, R. W. and HIGNETT, S. L. Chemotherapy in the treatment of chronic contagious mastitis. *Vet. J.* 1945, **101**, 88-94 and 99-108.

5. FRANCIS, J. A bacteriological examination of bovine tonsils and vaginas. *Vet. J.* 1941, **97**, 243-251.

6. FRANCIS, J. and STEWARD, J. S. The problems of bovine mastitis. *Vet. Rec.* 1944, **56**, 421-424.

7. NEAVE, F. K., SLOAN, J. K. B. and MATTICK, A.T.R. An outbreak of clinical mastitis involving 26 cows in a herd believed free from streptococcus agalactiae. (The role of milking machines in mastitis). *Vet. Rec.* 1944, **56**, 349-351.

8. WATTS, P. S. The milking machine as a factor in the incidence of mastitis. *Vet. Rec.* 1942, **54**, 181-184.

9. MURPHY, J. M., UDALL, D. H., JOHNSON, S. D. and TOMPKINS, L. J. Physical examination in the diagnosis of chronic bovine mastitis. *Cornell Vet.* 1944, **34**, 1-12.

10. GOULD, G. N. Bovine Mastitis. *Vet. Rec.* 1945, **57**, 287-289.

11. CRAWFORD, A. B. Experiences in the control of contagious abortion in cattle in the United States. *Vet. J.* 1944, **100**, 200-209.

12. HARING, C. M. and TRAUM, J. Effect of Br. abortus strain 19 on cattle of various ages and bearing on adult cattle. *J. Amer. Vet. Med. Ass.* 1941, **98**, 278-284.

13. GILVRAY, C. D. and GLOVER, J. S. Progress report of plans for the control of Bang's disease. Rpt. of the *Ontario Vet. Coll.* 1942, 16-18

14. HOLMAN, H. H. and MCDIARMID, A. An observation on reduction in milk yield following vaccination of lactating cows with living vaccines prepared from Brucella abortus. *Vet. Rec.* 1945, **57**, 335-336.

15. THOMSEN, AXEL. Does the bull spread abortion in cattle? Experimental studies from 1936 to 1942. *J. Comp. Path. and Therap.* 1943, **53**, 199-211.

16. ——————. Adult vaccination against brucellosis in cattle. Rpt. No. 3 of the *Amer. Vet. Med. Ass. Sub-Committee* on Brucellosis. *Jl. Amer. Vet. Med. Ass* 1944, **105**, 190-193.

17. HORTON-SMITH, C. and TAYLOR, E. L. Sulphamethazine and sulphadiazole treatment in caecal coccidiosis of chickens. *Vet. Rec.* 1942, **54**, 516.

18. HORTON-SMITH, C. and TAYLOR, E. L. Saturated solution of sulphamethazine as a substitute for drinking water in the treatment of caecal coccidiosis in chickens, *Vet. Rec.* 1943, **55**, 109-110.

19. HORTON-SMITH, C. and TAYLOR, E. L. Sulphamethazine in the drinking water as a treatment for caecal coccidiosis in chicks. *Vet. Rec*, 1945, **57**, 35-36.

20. HAWKINS, P. A. Sulphamethazine treatment of caecal coccidiosis. *Poultry Sci.* 1943, **22**, 459.

21. TEMPERTON, H. and BYTHELL, D. W. P. Six-day chick disease. *Vet. Rec.* 1944, **56**, 409-412.

22. TAYLOR, M. W. The six-day chick disease. *Modern Poultry Keeping*, 1944, **51**, 46-47.

23. WILSON, J. E. Observations on fowl paralysis and some current conditions in poultry problems. *Vet. Rec.* 1944, **56**, 521-524.

24. ASPLIN, F. D., DOBSON, N., GORDON, R. F. and BLAXLAND, J. D. Six-day chick disease. *Vet. Rec.* 1944, **56**, 466.

25. MCGAUGHEY, C. A. Six-day chick disease. *Vet. Rec.* 1944, **56**, 508.

26. GWATKIN, R. and MITCHELL, C. A. Transmission of Salmonella pullorum by flies. *Canad. Jl.* of *Pub. Health*, 1944, **35**, 281-285.

27. GORDON, R. F. and GARSIDE, J. S. Salmonella infections in ducks: observations on the value of the agglutination test in the eradication of infection and investigations on the cycle of infection *via* the egg. *J. Comp. Path. and Therap.* 1944, **54**, 61-76.

28. GORDON, R. F. Some recent advances in the control of poultry diseases. *Agric. Bull. Essex W. A.E.C.* 1945, **3**, 27-45.

29. GORDON, R. F. and BLAXLAND, J. D. Occurrence in England of outbreaks in poultry resembling the so-called pullet disease of America. *Vet. J.* 1945, **101**, 3-9.

30. BLAKEMORE, F. The nature of fowl paralysis. *J. Comp. Path. and Therap.* 1939, **52**, 144-159.

31. ASPLIN, F. D. Treatment of a virus disease of chickens with sulphonamides, *Nature,* 1944, **153,** 253.

32. BRITTON, J. W., MILLER, R. F. and CAMERON, H. S. Phenothiazine-salt mixtures in the control of parasitism. *Cornell Vet.* 1943, **33,** 339-343.

33. BRITTON, J. W. and MILLER, R. F. The practical application of anthelminitic medication of lambs. *J. Amer. Vet. Med. Ass.* 1944, **104,** 270-272.

34. PETERSON, E. H., KAMMLADE, W. G. and WEBB, R. J. The effectiveness of a 1-to-14 Phenothiazine-salt mixture in controlling nematode infection in sheep. *Amer. Jl. Vet. Res.* 1944, **5,** 228-233.

35. MORGAN, D. O. and SLOAN, J. E. N. Some observations on helminths in Scottish hill sheep. *Vet. Rec.* 1944, **56,** 436-437.

36. BRITTON, J. W. Phenothiazine in cattle practice. *Vet. Med.* 1944, **39,** 239-242.

37. GIBSON, T. E. The effect of small repeated doses of phenothiazine on strongylid infestation in the horse. *Vet. Rec.* 1945, **57,** 201-303.

38. GRIFFITH, A. STANLEY and MUNRO, W. T. Human pulmonary tuberculosis of bovine origin in Great Britain. *J. Hyg.* 1944, **43,** 229-240.

39. CUTBILL, L. J. and LYNN, A. Pulmonary tuberculosis of bovine origin. *Brit. Med. J.* 1944, No. 4338, 283-285.

40. TICE, F. J. Man as a source of bovine tuberculosis in cattle. *Cornell Vet.* 1944, **34,** 363-365.

41. McFARLANE, D., GARSIDE, J. S., WATTS, P.S. and STAMP, J. T. An outbreak of udder tuberculosis due to udder irrigation. *Vet. Rec.* 1944, **56,** 369-371.

42. BERGER, J. Tuberculosis of the genitalia in bovines and its implications. *Vet. Rec.* 1944, **56,** 469-470.

43. STEWARD, J. S. Bovine Tuberculosis: the examination under field conditions of bovine expectorate and discharges for M. tuberculosis. *Vet. Rec.* 1941, **53,** 521-527.

44. CANHAM, A. S. The tuberculin test in guinea pigs and cattle. The allergic response of animals to tuberculin and to extracts of non-pathogenic acid-fast bacteria. *Onderstepoort J.* 1944, **19,** 29-70.

45. CRAWSHAW, H. A. Nicotine poisoning in lambs. *Vet. Rec.* 1944, **56,** 276-277.

46. BARRON, N. S. Poisoning by Dog's Mercury (Merculialis annua. L.). *Vet. Rec.* 1944, **56,** 513.

47. HARE, T and ORR, A. B. Poultry poisoned by zinc phosphide. *Vet. Rec.* 1945, **57,** 17.

48. BLAXLAND, J. D. and GORDON, R. F. Zinc phosphide poisoning in poultry. *Vet. J.,* 1945, **101,** 108-110.

49. INGRAM, P. L. Zinc phosphide poisoning in a colt. *Vet. Rec.* 1945, **57,** 103-104.

50. GALLIE, J. G. E. and PATERSON, J. D. Charlock poisoning of lambs. *Vet. Rec.* 1945 **57,** 198.

51. PIERCY, P. L., HARGIS, G. and BROWN, C. A. Mushroom poisoning in cattle. *J. Amer. Vet. Med. Ass.* 1944, **105.** 206.

52. KING, F. G., BARRICK, F., HOEFER, J. A., and DOYLE, L. P. Diagnosis of poisoning of beef calves by lead paint. *J. Animal Sci.* 1945, **4,** 20 23.

53. WATSON, A. H. and ADAMS, A. J. Lead poisoning by salvaged soya bean meal. *Vet. Rec.* 1945, **57,** 161.

54. LOVELL, R., LEVI, M., and FRANCIS, J. Studies on the survival of Johne's bacilli. *J. Comp. Path.* and *Therap.* 1944, **54,** 129.

FARM ECONOMICS

I. RURAL RECONSTRUCTION.

During the fifth year of the war, a growing tendency was manifest to consider the problems which peace would bring. Official committees, University departments and private groups have set themselves to investigate conditions affecting one or other of the phases of rural life and labour, as a basis for the improvement of economic and social conditions. Some of these have completed their work and have published their conclusions.

Of the surveys and investigations made last year, perhaps the most extensive in its scope is a study of the agriculture of Wales and Monmouthshire made by Professor A. W. Ashby and Principal Ifor Evans, of Aberystwyth. It deals with the recent history of Welsh agriculture and the changes which it has undergone, particularly between the two wars. Changes in the cropping of the land and in the classes and numbers of livestock are recorded in great detail, and the influence of such things as competing imports, marketing organization and farm mechanization, on farm organization, on the financial results of farming, and on employment in agriculture are fully discussed. Thus, dairy farmers in Wales were heavily hit in the years before the war by the increasing volume of imports of butter and cheese and the heavy break in markets which followed. Under the operations of the Milk Marketing Scheme, introduced in 1933, more and more milk was diverted from farm manufacture into the liquid market, and the number of registered producers rose by no less than 90 per cent. in five years, representing approximately one-half of the full-time farmers of Wales.

In the Principality, as elsewhere, there has been a steady decline in the population engaged in agriculture. The number of farmers shows little change, but there has been a decline in the number of farm labourers of all kinds amounting to approximately 8 per cent. since the beginning of the century. By comparison, it is interesting to note that in the English counties the fall was no less than 25 per cent. and the steadier rate of employment in Wales reflects, of course, the higher degree of peasant farming. There are many farmers in Wales who employ no labour outside the family, and farms generally are too small to admit of mechanization of labour processes on the scale which has done much to reduce labour staffs on the larger English farms. In most parts of Wales, the family farm is firmly established on an agelong tradition. Welsh farmers, too, have developed a co-operative organization for many purposes, to their mutual advantage. Whether tradition and mutual association in business will enable them to overcome the patent handicaps of small-scale operations indefinitely, remains to be seen. It is clear that the authors have this problem very much in their minds, while leaving their readers to draw their own conclusions as to the future trends of Welsh agriculture (Ref. 1).

Another investigation, this time of a small area only, but carried out intensively into

every phase and circumstance of rural life, emanated from the Agricultural Economics Research Institute, at Oxford. A group of some twenty parishes in a rural area of a midland county was investigated by a survey team, selected for the special aptitudes of its members for the various parts of the work. The matters investigated included the ownership of the land, the efficiency of its layout in farms and fields, and the adequacy and condition of its permanent equipment for modern farming. There was an examination of rural housing and the public services connected with it; of the standard of local government; of the health services and of rural education, while the religious and social organizations of all kinds were brought under review, as having an important part to play in the life and well-being of the rural community.

This investigation brought out, at once, the need in this district, and probably in many others, for a rectification of the boundaries of many farms and fields, in the interests of efficiency in farm management. (This is a need which many of the County War Agricultural Executives have encountered, and they have attempted improvements in some of the worst cases). Rural housing and matters such as public water supplies, electric light and power, and sewerage, were markedly deficient, and these are matters calling for remedy if rural labour is to enjoy the amenities of life which every town dweller takes for granted.

These things, however, are already in the public mind, and some improvements are foreshadowed. It is in the social life of the countryside that the investigation brought to light a far more serious difficulty. Very many rural communities are too small to give reasonable opportunities to their members. They cannot support, some of them, even junior schools, they cannot run a Women's Institute or raise cricket and football teams, and often the young people are too few to organise such things as Scouts, Guides and Young Farmers' Clubs. Herein lies the explanation probably, of the lure of the town. It constitutes a real problem, affecting the supply of labour for the land in the future, and the solution has not yet been found. The report on this investigation, published at the close of last year, suggests that the decentralization of industry and the repopulation of the smaller villages which this might bring, if carefully planned and carried out in co-operation with the local administrative authorities, might do much to regenerate village life and to provide useful local markets for much of the farmer's more valuable products (Ref. 2).

For a summary of the arguments for town and country planning, admirably illustrated and well-documented, readers may be referred to a publication in the series *Target for To-morrow*. Though dealing largely with the congestion of our towns, there are sections dealing with the need for better housing and public services in rural areas, and the authors, Phoebe Pool and Flora Stephenson, support the argument for decentralization in the interests of town and country alike (Ref. 3).

Closely allied to the foregoing investigations of the economic and social condition of the countryside is the work carried out by the Rural Housing Sub-Committee (the Hobhouse Committee) of the Central Housing Advisory Committee appointed by the Minister of Health. Its Third Report, published last year, is a valuable picture of rural housing as it exists to-day, "together with a fair assessment of the performance of the responsible authorities and suggestions for its improvement in the future." It is noteworthy that the Sub-Committee's recommendations are concerned mainly with administrative measures, and they do not call, for the most part, for legislative action. Thus, they involve no hindrance to speedy action directly conditions in the building trade make a new start possible.

The Report envisages that most of the new building needed in country districts will devolve upon local authorities. On the whole, the Sub-Committee is satisfied to leave the main responsibility with the Rural District Councils, but with closer co-operation with the County Councils in the form of Joint County Committees on Rural Housing. At the same time, the place of the private landowner and builder in the general scheme is recognised,

and there are proposals for bringing the assistance afforded by the Housing (Rural Workers) Acts more into line with probable post-war building costs. Further, it is pointed out that the subsidy of £10 payable on a house annually for 40 years, as an encouragement to the private builder, is useless to-day, when farm workers' houses are costing about £1,000. To let such houses at 8s. a week, exclusive of rates, and to give the landowner a return of no more than 3 per cent. on his capital, would call for a subsidy of £24 16s. annually for 40 years.

One of the many practical recommendations of the Sub-Committee is for a survey of housing conditions in Rural Districts, to be undertaken by the Joint Housing Committees. This survey would supply information as to (1) houses requiring repairs ; (2) houses requiring reconditioning ; (3) houses requiring demolition ; (4) new houses needed to replace those demolished and to relieve overcrowding. Local authorities could then draw up their long-term programmes based upon accurate knowledge (Ref. 4).

II. FARM MANAGEMENT.

(a) *The New Zealand Dairy Industry.*

In quite a different category, and coming from the other side of the world, is a valuable report of the dairy industry in New Zealand. Most farmers in this country are aware of the great and rapid expansion of the volume of exports of butter and cheese to the British market, which has made New Zealand the great competitor of Denmark for the butter market and of Canada for the cheese market of this country. This development was made possible by the invention of refrigerated carriage of produce at the beginning of the century, which was soon to be associated with the cream separator and later with the milking machine. It was home separation which rendered possible the rapid expansion of the butter factory system, and the milking machine and the electric motor which increased so greatly the efficiency of labour.

The report is a record of wonderful progress, but criticism is made of some parts of the organization. British dairy farmers will be particularly interested in the conclusions as to the future of the industry. Relying on the growing awareness of the problems of malnutrition in this country, the report anticipates a growing demand for imports of dairy products, particularly of butter, while the demand for cheese, which has been much more stable in the past, may also show some increase.

It is commonly maintained in this country that butter exports from New Zealand are heavily subsidized by the Government of that country, and it is of special interest, therefore, to turn to that section of this report dealing with subsidies. The author of the report, W. M. Hamilton, of the Department of Scientific and Industrial Research, Wellington, deals very fully with the matter. Except for liquidation of the initial deficit of some £276,000 resulting from the first year's operation of the guaranteed-price plan, the New Zealand Dairy farmer has not been directly subsidized. There is assistance given, however, to all farmers to meet freights on fertilizers, the cost of pest and weed destruction, live-stock improvement, and so on, which amounted to something over a million pounds in the year 1940-41. In the same year grants for education and research amounted to nearly another half million. The author estimates that somewhat less than half these totals are of benefit, directly or indirectly, to the dairy industry, an amount equivalent, approximately, to 6s. per cow. (Ref. 5).

(b) *Financial Results and Costs of Production.*

For reasons good and sufficient, no doubt, though not always obvious, the published results of many investigations of the financial results of farming and of costs of production are marked 'Confidential,' and it is impossible, therefore, to make use of them for the information of farmers generally in this summary of the year's research.

(*i*) *General.* For several years past, a general Farm Management Survey has been in progress, covering upwards of 2,000 farms in various parts of the country. The work has been carried out locally, at the Advisory Centres, and the figures are tabulated and summarized at the Agricultural Economics Research Institute. Farms are classified for purposes of comparison into three groups,—those mainly grass, those mainly arable, and mixed farms. Within these groupings, there are sub-divisions—grass farms, for example, being split up into 'mainly dairying,' 'dairying and mixed,' 'mixed livestock' holdings, and there are appropriate sub-divisions of the other groups. Reports are issued by the Institute at Oxford from time to time, showing the results on these grouped holdings, to give a general picture of the fortunes of farming in these broad types of enterprise. At the same time, with the assistance of the Advisory Economists, it is possible to produce figures within each of these types for local area groups. Thus, 'grass farms mainly dairying' are subdivided into territorial groups representative of the principal dairying districts of the country, enabling comparisons of methods and results to be made between one and another, and the same practice is followed with the farms comprised in the rest of the principal groupings.

The latest report refers to the year 1942, and the experiences of farmers on 1,828 farms in that year are contrasted with those of 1941. Taking the results of the three main groups as a whole, farmers earned satisfactory margins, which were identical, as it happens, in the two years. Dividing the farms into the three main groups, it is notable how much arable farming has come into its own, and that the margins, both on the farms mainly arable and on the mixed farms, were substantially higher than those on the various types of farms mainly grass.

Turning to the analysis of the figures, the wartime change from grass to ploughland is reflected in the accounts. As between 1940 and 1942, the amounts spent per 100 acres on seeds rose by 105 per cent., on fertilizers by 50 per cent., and on machinery and implements more than 60 per cent. The cost of labour rose by 55 per cent., while rent, it is interesting to note, was practically stationary, and expenditure on feeding-stuffs dropped by 55 per cent. Another interesting figure is the cost of repairs to implements and machinery, now such an important item in the equipment of most farms. On this group of holdings it amounted to £20 per £100 of capital invested in machinery, etc. Direct Government grants, averaged over all farms, amounted to £11 per 100 acres, or 13s. 7d. per £100 of receipts. The report contains a comparative statement of the net farm earnings disclosed by the survey, yearly, since 1936 (Ref. 6).

Arising out of the same national farm management survey, the Economics Section of the Department of Agriculture, Leeds, have issued their usual yearly analysis of financial results of Yorkshire farming. A total of 185 farms have been divided into groups representing nine types of Yorkshire agriculture, from heavy land corn-growing farms in Holderness, to the intensive arable farming of the Plain of York, and the corn and sheep of the Wolds and of other light land types; and from the intensive dairy holdings of the industrial districts, where milk is largely producer-retailed, to Swaledale with its milk production for the wholesale market on the one hand, and its sheep farms on the other hand.

The capitalization of these types show considerable differences, ranging from something less than £10 an acre in Holderness and about £12 in the Wolds, to £15 in the Plain of York and £25 per acre on the intensive dairy holdings of the West Riding. In Swaledale an acreage figure for the cost of farm stocking is not comparable with those of the other districts, owing to the varying proportions of hill and valley land on the different holdings.

Farming in the Plain of York makes the best showing, being twice as profitable as in Holderness, and the intensive milk-producers figure as runners-up. There is an interesting table in the report showing the output and the profit per £100 of labour expenditure. The

big Wold farms seem to make the most economical use of man power, as measured by the wages bill, and the intensive milk-producers the worst, the difference being explained, in whole or in part, by the higher rates of wages demanded in the more industrial districts (Ref. 7).

(*ii*) *Livestock Products.* Two reports on the cost of winter feeding of cattle have appeared during the year. The first of them, emanating from the University of Leeds, deals with yard feeding on eleven farms in the winter of 1943/44; 421 bullocks were involved, and it is of some interest to note that no fewer than 347 of these were bought as Irish stores. Of the remaining 74, only 14 were bred on the farms where they were fattened. Prices, both for stores and for fat cattle, showed a marked increase on previous years, and the length of the feeding period has gone steadily up from pre-war years, as the amount of available concentrates declined. In the result, heavy losses on feeding occurred, the average per beast being between £6 and £7, after crediting the value of manurial residues. It is understood, of course, that bullock-feeding is not an isolated enterprise on most farms, forming, as it does, part of an inter-acting system in which livestock are used to convert straw into manure for the maintenance of soil fertility. On these Yorkshire farms, the manure had to be worth about £1 a ton if bullock-feeding was to pay for itself. (Ref. 8).

The other report comes from the Department of Agricultural Economics, Aberystwyth, and concerns some 600 cattle fed on 26 farms in various parts of Wales in the winter, 1942/43. As in the Yorkshire investigation, the cattle were out on pastures during the early part of the winter. Profits were recorded only on 5 farms, and over all there was an average loss of about 10s. per head. The authors of the report attribute this to the difficulty of ensuring a balanced diet owing to restriction on the use of purchased concentrates. Several of the farmers maintained that they were obliged to give hay as the main part of their bulk feed because of the high protein deficiency of the straw which they would have preferred to use. The investigators suggest that this could be remedied by more careful planning of the cropping programme, to secure a better protein-starch ratio in the available feed. There has been too great an emphasis, they say, on the cereal crops and too little on the pulses, in war-time cropping in Wales. (Ref. 9).

The financial results of sheep breeding and feeding, extending over the six years 1938/9 to 1943/4, on the College farm at Wye, have been dealt with in a summary report by the Advisory Economist there. A flock of about 300 half bred ewes was involved; only 12 ewes were sold as barrens over the whole period, and the death-rate was 7.2 per cent. Lambs tailed averaged 147 per cent., the range being from 136 to 155; and the death-rate after tailing was only 1.6 per cent. The flock was kept entirely on grassland, and to an increasing extent on rotation pastures, the stocking being equivalent to about 3.35 ewes per acre per annum. The average weight per lamb ranged from 62.7 lbs. to 75.8 lbs., and this represented not so much random fluctuations as a fairly steady decline, following, first, the reduction, and after 1940 the elimination, of corn and cake feeding to the lambs. Prices realised, however, rose even more steadily than the fall in weight, from about 5d. per lb. live-weight in the first year to nearly 9½d. in 1943/4. The total profit from the breeding flock for the six years to Michaelmas 1944, before charging anything for the manager's salary, was equivalent to about 41 per cent. per annum on the capital invested in sheep and sheep equipment. (Ref. 10).

Poultry farming has been carried on with difficulty during the war years, owing to the shortage of available food, but the evidence shows that changes have been less severe in Wales than in some other parts of the country. Reports of the financial results of poultry keeping for the years 1942/3 and 1943/4 have been issued by the Department of Agricultural Economics, Aberystwyth. Costs per bird fell from 25s. in the former years to 23s. in the latter, but there were wide variations between individual flocks. Food accounted for more than half the cost, and rose slightly between the years, but labour was unchanged at about

6s. 8d. per bird. It should be noted that this does not represent wages for hired labour, but an estimate of family labour priced at current wage rates. Such a charge must be regarded, it is pointed out, as part of the income of the owner and his family. The average number of layers was about 130 birds per flock in each year, but the balance of profit on these numbers increased from about £64 in 1942/3 to £122, nearly double, in 1943/4. This increase is attributed mainly to the fact that the breeders, as a group, made greater use, in the second year, of the high priced market for hatching eggs and day-old chicks than did the group recorded in the previous year, for total costs varied very little. (Refs. 11 and 12).

The importance of milk production, both for higher quantity and better quality, is constantly impressed upon farmers, and more money is invested in it than in any other livestock product. With the encouragement of the Milk Marketing Board, investigations of the economics of dairying have been carried out for some years past at every research centre in the country, and a number of reports on costs, financial results and on herd management have been issued during the past year. One of these, coming from the South Eastern Agricultural College, at Wye, covers a six-year period which began with the year 1937-8, on the College farm, and relates to a herd of about 30 cows. The herd and its equipment represent about 25 per cent. of the total farm capital, but while it contributed some 28 per cent. of the farm revenue over the period under review, it accounted only for about 12 per cent. of the total farm profit. This is a reflection, no doubt, of the emphasis during wartime on cereal production, and the priority given to it by price regulation. Nevertheless, the analysis of costs and returns shows that there was an average profit of £11 4s. 9d. per cow per annum over the whole period and of 4½d. per gallon of milk. The average milk yield per cow was 593 gallons. As the war proceeded, the grazing, which had been almost entirely permanent pasture to begin with, changed by stages until it became mainly rotation grass. Similarly, home-grown cereals and beans came to be substituted more and more for the concentrated part of the cow's rations. In the years 1937/40, half the cost of feeding was due to purchased concentrates, but the proportion had dropped to one-third in the next three years.

With this exception, there was a steady rise in all items of cost. Labour increased by 2d. a gallon, and total foods by 3½d. Allowing for smaller items, total costs rose by almost exactly 6d. a gallon, while returns increased by nearly 8½d. per gallon of milk.

The depreciation on the herd over the six-year period represented an annual cost of £3 10s. 0d. per cow, equivalent to almost 1½d. per gallon of milk. The herd is Tuberculin Tested, and free from abortion and mastitis. (Ref. 13).

Other reports on milk production costs in recent years, both for winter and summer periods, have been issued by the Advisory Economists at Leeds, Aberystwyth, the Midland and the Harper Adams Agricultural Colleges, and they are available to those interested in milk production in these localities. (Refs. 14-22).

Grass, as it is well known, is the cheapest food for livestock, and the Farm Economics Branch, Cambridge University, conducted an investigation on the cost of grazing in connection with milk production by 52 herds in the year 1942/43. Charges ranged from less than 20s. on 3 farms, up to 50s. per acre and over on 7 farms. Pasture improvement, it is stated, is commonly the key to better returns for milk production, and improvement should aim at lengthening the grazing season at each end. This problem is immediately associated with re-seeding, and the Cambridge report includes an analysis of experiences of this on ten farms in the Eastern Counties. (Ref. 23).

Startling statements are made from time to time as to the enormous losses to farmers and food production arising out of animal diseases. While these must be very great, there is little statistical information available to show the effect of the commoner ailments upon livestock production costs. Special interest attaches, therefore, to a report from the Harper

Adams Agricultural College on the estimated financial loss due to an outbreak of Trichomonas Disease in a commercial dairy herd. The dairy in question had a normal strength of 58 cows, with an average daily output of about 180 gallons in summer and 80 gallons in winter. Following an outbreak of the disease diagnosed in May, 1942, and treatment of the animals throughout the summer, the average daily winter gallonage dropped to 30 gallons in the first winter period, and it had risen only to 40 gallons in the second winter period, though it is surprising to note that there was no material decline during the intervening summer period.

The report records a loss of £1,680 on this herd of 58 cows, due to decline of milk yields, replacement of cows, loss in calves, and increased cost of veterinary attendance and medicines. (Ref. 24).

(*iii*) *Crops.* Sugar beet has occupied a position quite unique amongst farm crops since its first introduction into general farming twenty years ago. Up to the outbreak of the war, it existed only with the aid of a fairly heavy subsidy paid on the production of home-grown sugar, and while it was of real value to farmers as giving them a cash root crop, the sugar was of no special advantage to the consumer. The whole situation was changed, however, by war-time conditions, and it is understood that the bulk of the nation's sugar supply has been derived from home-grown beet. The cultivation of the crop is now pretty well understood, and the regular costings which were properly undertaken at several centres in earlier years, have most of them lapsed. It is of interest, therefore, to see some figures emanating from the Harper Adams Agricultural College, on yields and costs in 1944, on certain farms growing for the Allscott factory. The year was a bad one both for yield of washed beet and for sugar content. Germination was poor and growth slow during an exceptionally dry spring, in fact, the yield was the lowest since the year 1931. Total costs were £35 an acre, an increase of more than £3 on the year 1942, due almost entirely to higher manual labour costs, and costs of artificial manure and lime. (Ref. 25).

In a report on the cost of winter beef production in Wales, referred to above (Ref. 9), comment was made on the need for a better balance between the production of cereal crops and pulses on the farm, now that high protein foods on the market are in short supply. It was natural, therefore, that the Department of Agricultural Economics at Aberystwyth should have investigated the methods and costs of growing beans for farm livestock.

The acreage under beans in Wales has already shown a great increase, having risen from under 400 acres in 1939 to more than 6,000 acres in 1943. The Aberystwyth report goes into all the conditions for successful cultivation in great detail, and the costs of all the operations involved have been recorded on 19 farms. A heavy-land crop, the advantage of tractors over horses is clearly shown, and the higher cost of contract work, in contrast with that of similar operations done by farmers' own tractors, is apparent. Though there were great variations in yields and costs between farm and farm, beans were a profitable crop, and this report is full of information likely to be of value to Welsh farmers unfamiliar with it. (Ref. 26).

Though the volume of information, year by year, on farming costs of all kinds is now very considerable, little work seems to have been done on market gardening and vegetable crops. Of special interest, therefore, are two reports, the first on methods and costs of production of parsnips, carrots, onions, broad beans and certain brassicas in Carmarthen and the Gower peninsula, coming from Aberystwyth ; the other, limited to the costs of growing autumn and spring cabbage in Yorkshire, is published by the Economics Section of the Department of Agriculture, Leeds. (Refs. 27 and 28).

Another crop which has sprung into importance during the war is flax, whether grown as a farm food or for fibre. As a farm food, it was studied by the agricultural economists at Aberystwyth, its cultivation being a new experience for the present generation of Welsh farmers. The older men remembered linseed, either alone or in mixtures with cereals, as

fairly common in certain districts some fifty years ago, being particularly valued for calf feeding and for putting a bloom on horses which were being got up for sale.

Crops on twenty-one farms were studied in 1944, eleven of them being first experiences, and only on one farm had the crop been grown before the war. Valuable details of farmers' experiences are given in the report. The average yield was little more than 6 cwt. an acre, representing an average cost (including failures) of £1 11s. 0d. per cwt., which contrasted with the controlled price for the year of £1 7s. 6d. For the best two crops, however, which yielded 12 cwt. and 17 cwt., the costs were as low as 17s. and 13s. respectively (Ref. 29.).

Flax grown for fibre has been under review by the Economics Department of the Edinburgh and East of Scotland College of Agriculture for the past few years, and in 1943 their investigation covered 895 acres, comprised in 73 crops. All these were grown under contract for one or other of the factories at Coupar and Blairgowrie. Details of the places occupied by flax in the crop rotation are given, together with soil types, rental values and details of the effects of elevation on the crop. Flax can only be grown on land approved by the factories and from seed supplied by them ; growers are expected to follow advice given them on matters of cultivation, manuring and harvesting. Costs of production ranged from £9 7s. 0d. to £21 10s. 0d. The average, £13, was practically identical with that of the previous year. Payment is made by grade, and at the contract prices payable for the various grades. Scottish growers of flax should be well satisfied with the results as disclosed in this report. (Refs. 30 and 31.).

(*iv*) *Labour Studies.* Labour costs will surely be the dominating factor in farm economics in the post-war period. The increases in wages of the war years are likely to be permanent, and if there is to be any marked fall in farm prices, the problem of farm organization so as to earn the necessary money must be solved. It is a problem to which farm economists might well devote more attention.

A report on general labour costs in the war years which has been issued by the Department of Agricultural Economics, Aberystwyth, contains all the materials for stating the problem. By September, 1944, weekly wages in Wales were 84 per cent. higher than those in September, 1939, while the costs of labour per 100 acres are shown to have doubled during this five year period. The additional 33 per cent. of increase is due to a rise in the number of workers employed and to more overtime employment. It was not the purpose of the investigation to say how these increases should be met in times of lower prices. (Ref. 32).

One of the means by which to increase the efficiency of labour is the greater use of machinery, and in this connection the Farm Economics Branch of the Cambridge Department of Agriculture has made a study of the comparative costs of harvesting by combine-harvester and by reaper-and-binder. A straight comparison is not possible, for there are alternative ways of dealing with the harvest by either machine. The crop from the binder may be stacked and threshed, or it may be threshed straight out of the field ; the straw from the combine may be swept and stacked, or it may be baled, or burnt, or ploughed back into the soil. The financial advantages of either machine are materially affected by the methods adopted for dealing with the crops after cutting.

A twelve-foot combine could cut and thresh about 300 acres, and smaller sizes in proportion, but there was a small saving in cost on the largest size. On 10 farms the total field cost averaged 19s. an acre. To this has to be added the cost of dealing with the straw, which varied from 1s. 4d. an acre for burning and ploughing in, to 20s. 8d. for baling. Total cost of harvesting by combine, therefore, varied from 20s. 4d. to 39s 8d. an acre, contrasted with 42s. 1d. for harvesting by binder if threshed from the field, or 63s. 3d. if stacked, thatched and threshed.

The investigation found not only a saving of cost in favour of the combine, but also a substantial saving in labour, a small combine needing only half as much manual labour per acre as a crop cut by binder, and the large ones showing an even greater saving (Ref. 33).

With the co-operation of members of Young Farmers' Clubs, the cost of using tractors as sources of farm power was studied on a few farms in the Clyde Valley, by the Economics Department of the West of Scotland Agricultural College. Details of cost, such as fuel, lubricant, repairs, parts and overhauls, depreciation and service time, are given in a first report, but perhaps the most useful point which emerges for the attention of farmers is the importance of working a full day, and as many days as possible. The average cost per hour of tractors working over 1,000 hours was about 22½d. ; for those working under 1,000 it was 30d. (Ref. 34).

c. Economics of Hill Sheep Farming.

Two Government publications dealing with hill and upland sheep farming the one in England and Wales and the other in Scotland, were published during the year. The area of rough grazings and the contribution which they can make to the food supply of the nation are considerable, but poor returns have necessitated a Government subvention in order to save the hill sheep industry. The economic uncertainty is very considerable. Bad weather at lambing time may cause heavy losses both of ewes and of lambs, while the fluctuations in farm prices for store lambs, draft ewes and wool are severe. Cheviot lambs sold for 46s. in 1924, for 10s. 9d. in 1932, and for 14s. 6d. in 1939 ; the corresponding prices for draft ewes in the same years were 60s., 55s. and 26s. For wool, the figures were 24d., 7½d., and 12½d. Both reports contemplate a conflict of interest between forestry and farming in the Highlands, but this possibility is reduced by the recent alteration in the status of the Forestry Commission, which is now a department of the Ministry of Agriculture.

The recommendations of the Committees cover a wide field, including schemes for the control of disease, the control of rams, the provision of better dipping facilities, the possibility of improving the quality of hill sheep stock without loss of hardiness, legislation to clarify the rights and obligations of the users of common land, control of the stocking of grazings, and better amenities and communal services for upland communities. Research and legislation are directly involved before conditions are likely to be more satisfactory. (Refs. 35 and 36).

III. FOOD SUPPLIES.

In May, 1943, the United Nations Conference on Food and Agriculture held at Hot Springs, Virginia, U.S.A., resolved to set up an Interim Commission to formulate and recommend for consideration by each member Government a specific plan for a Government organization in the field of food and agriculture.

This refers to the famous and already almost forgotten declaration of the primary importance, in the post-war period, of international action to secure " freedom from want." In a Government publication recently issued, the documents relating to this Commission, its constitution and functions, are set out, and those interested in this bold conception of a plan to raise the levels of nutrition and standards of living of many nations, by securing improvements in the efficiency of the production and distribution of all food and agricultural products, 'and thus contributing towards an expanding world economy,' will find in it the fullest information of its scope. (Ref. 37).

Continuing its work on war-time food rationing and consumption, the League of Nations has produced a study of the amount, composition and nutritive value of the legal food rations in various countries towards the end of 1943. As a study of war-time nutrition would be incomplete without some reference to public health, this is followed by a few illustrations of certain tendencies in particular areas. The most serious symptom of

malnutrition proved to be tuberculosis, the mortality from which was estimated to have increased by no less than 50 per cent. in France. The publication concludes with an estimate of production and supply which seems to suggest that in the fourth war year, the total consumption of food may have declined to roughly two-thirds of the immediate pre-war average. Details of production are given for most of the European countries (Ref. 38).

The pooling, in principle, of the entire food resources of Great Britain, Canada, and the United States necessitated the creation of a Combined Food Board to secure a common basis of calculation of rates of commodity consumption in the countries concerned, and for a consideration of their diets as a whole. In March 1943, this Board resolved to set up a Committee of experts to study and compare 'the pre-war, present and prospective food consumption levels' of these countries. Its report was issued last year as a Government publication, and it contains valuable statistical information both on nutrition requirements, and on the nutrients available during the war years. (Ref. 39).

IV. MISCELLANEOUS.

One of the greatest problems confronting the Allied Nations in the resettlement of Europe is the agrarian problem in the peasant countries. From the Baltic to the Aegean, particularly, stretches a great area populated, in the main, by peasant peoples, unassociated with industrial development and forced to follow an organization of agriculture giving, relatively, a low standard of living. In Russia, the economic weakness of food production on small peasant holdings is being mitigated, it is understood, through the organization of collective farms. A pamphlet issued by the Royal Institute of International Affairs discusses the peasant problem and formulates a peasant programme. (Ref. 40). In another pamphlet, a Soviet agricultural scientist sets out to answer the question which has puzzled many people in this country,—'what are collective farms?' (Ref. 41).

C. S. ORWIN.

AGRICULTURAL ECONOMICS RESEARCH INSTITUTE,
OXFORD.

References

I. RURAL RECONSTRUCTION.

1. ASHBY, A. W. and EVANS, I. L. The Agriculture of Wales and Monmouthshire. *Cambrian News.* 1944.
2. AGRICULTURAL ECONOMICS RESEARCH INSTITUTE. Country Planning. A Study of Rural Problems. *Oxford University Press,* 1944.
3. POOL, P. and STEPHENSON, F. A Plan for Town and Country. Target for To-morrow No. 2. *The Pilot Press, Ltd.* 1944.
4. Rural Housing. Third Report of the Rural Housing Sub-Committee of the Central Housing Advisory Committee, Ministry of Health. *H.M. Stationery Office.* 1944.

II. FARM MANAGEMENT.

a. The New Zealand Dairy Industry.

5. HAMILTON, W. M. The Dairy Industry of New Zealand. Bulletin 89. *Council of Scientific and Industrial Research, New Zealand.* Wellington, New Zealand, 1944.

b. Financial Results and Costs of Production.

(i) General.

6. Farm Management Survey. Preliminary statement of financial results for 1,828 farms in 1942. *University of Oxford: Agricultural Economics Research Institute.* 1944.
7. The Economic Organization of Some Types of Farming in Yorkshire, 1942/3. Farmers' Report No. 48. *University of Leeds: Department of Agriculture.* 1944.

(ii) Livestock and Livestock Products.

8. Costs of Winter Fed Cattle, 1943/44 Farmers' Report No. 52. *University of Leeds: Department of Agriculture.* 1944.
9. THOMAS, W. J. and ROBERTS, M. B. Costs of Yard Fattening of Cattle in Wales during the Winter Period 1942-3. *Department of Agricultural Economics, University College of Wales, Aberystwyth.*

10 Wyllie, James. Financial Results on the College Farms. IX. Sheep Breeding and Feeding over Six Years, 1938/9 to 1943/4. *Department of Economics, South-Eastern Agricultural College, Wye, Kent.*

11. Thomas, W. J. Financial Results of 29 Poultry Farms in Wales, 1942-3. *Department of Agricultural Economics, University College of Wales, Aberystwyth*, 1944.

12 Thomas, W. J. Financial Results of 37 Poultry Farms in Wales, 1943-4. *Department of Agricultural Economics, University College of Wales, Aberystwyth*, 1945.

13. Wyllie, James. Financial Results on the College Farms. X. Milk Production over six years, 1937/8 to 1942/3. *Department of Economics, South-Eastern Agricultural College, Wye, Kent.*

14. Summer Milk Production Costs in Yorkshire. (April to September, 1943). Farmers' Report No. 45. *University of Leeds Economics Section, Department of Agriculture* 1944.

15 Milk Production Costs in Yorkshire, 1942/43. Farmers' Report No. 46. *University of Leeds: Economics Section, Department of Agriculture*, 1944.

16. Winter Milk Production Costs in Yorkshire, 1943/44. Farmers' Report No. 49. *University of Leeds: Economics Section, Department of Agriculture.* 1944.

17 Summer Milk Production Costs in Yorkshire. (April to September, 1944) Farmers' Report No. 53. *University of Leeds: Economics Section, Department of Agriculture* 1945.

18 Milk Production Costs in Yorkshire, 1943/4. Farmers' Report No. 54. *University of Leeds. Economics Section, Department of Agriculture.* 1945

19 Pryse Howell, J., Griffiths, J D., and Phillips, J. R E. Comparison of Costs of Winter Milk Production, 1941-42 and 1942-43. *Department of Agricultural Economics, University College of Wales, Aberystwyth.*

20. Milk Production Investigation. Comments on the Year Ending 30th September 1944 and a Comparison of the Results from 61 Identical Herds for the years 1942 43 and 1943-4. *Economics Department, Midland Agricultural College* 1945.

21. Phillips, J. R. Cost of Milk Production, 1943-44. MacGregor, J J. and Peregrine, F. A. W Some Standards of Efficiency in Milk Production. Farmers' Report No. 22. *Department of Economics, Harper Adams Agricultural College, Newport, Shropshire.*

22. Phillips, J. R. Cost of Milk Production for Winter Period 1943-4 and Winter Feeding of Dairy Cattle for Six Years on 18 of the Farms Costed. Farmers' Report No. 21. *Department of Economics, Harper Adams Agricultural College, Newport, Shropshire.*

23. Grazing Charges, 1942-43, and Milk Production with a Note upon Direct Re-Seeding. War Series Report No. 26. *University of Cambridge: Department of Agriculture.*

24. MacGregor, J. J. and Shaw, I. G. Estimated Financial Loss caused by an outbreak of Trichomoniasis in a Commercial Dairy Herd. Farmers' Report No. 23. *Department of Economics, Harper Adams Agricultural College, Newport, Shropshire.*

(*iii*) *Crops.*

25. Cook, B. M. A Survey of the Costs of Production of the 1944 Sugar Beet Crop in Shropshire. *Department of Economics, Harper Adams Agricultural College, Newport, Shropshire*, 1945.

26. Thomas, W. J. Growing Beans for Welsh Livestock: Methods and Costs. *Department of Agricultural Economics, University College of Wales, Aberystwyth.* 1944.

27. Beynon, V. H. Report on Methods and Costs of Production of some Vegetable Crops in S.E. Carmarthen and the Gower Peninsula. *Department of Agricultural Economics, University College of Wales, Aberystwyth.* 1944.

28. Some Costs of Growing Autumn and Spring Cabbage in Yorkshire, 1943-1944. *University of Leeds: Economics Section: Department of Agriculture.* 1944.

29. Thomas, W. J. and Roberts, M. B. Some Experiences in Growing Linseed for Feed on Welsh Farms. *Department of Agricultural Economics, University College of Wales, Aberystwyth*, 1945.

30. Economics of the 1942 Flax Crop in the East of Scotland. *Edinburgh and East of Scotland College of Agriculture: Economics Department*, 1945.

31. Economics of the 1943 Flax Crop in the East of Scotland. *Edinburgh and East of Scotland College of Agriculture: Economics Department* 1945.

(*iv.*) *Labour Studies.*

32. Smith, J. H. Farm Costs of Hired Labour in Wales during 1943-4. *Department of Agricultural Economics, University College of Wales, Aberystwyth*, 1945.

33. Harvesting by Combine and Binder. *Farm Economics Branch, Cambridge University, Department of Agriculture*, 1944.

34. Farm Power Studies. No. 1 Tractor Costs. *West of Scotland Agricultural College, Economics Department.*

c. Economics of Hill Sheep Farming.

35. Report of the Committee on Hill Sheep Farming in England and Wales. *Cmd.* 6498. *H.M. Stationery Office*, 1944.

36. Report of the Committee on Hill Sheep Farming in Scotland. *Cmd.* 6494. *H.M. Stationery Office*, 1944.

III. FOOD SUPPLIES.

37. Documents relating to the Food and Agriculture Organization of the United Nations. 1st August-14th December, 1944. *Cmd.* 6590. *H.M. Stationery Office*, 1945.

38. League of Nations. Food Rationing and Supply 1943-44. *League of Nations*, 1944.

39. Food Consumption Levels in the United States, Canada and the United Kingdom. Report of a Special Joint Committee set up by the Combined Food Board. *H.M. Stationery Office*, 1944.

IV. MISCELLANEOUS.

40. Royal Institute of International Affairs. Agrarian Problems from the Baltic to the Aegean. *Oxford University Press*, 1944.

41. Karpinski, V. A. What are Collective Farms? *Lindsay Drummond, Ltd.*, 1944.

THE FEEDING OF LIVESTOCK

NUTRITION OF DAIRY COWS AND BEEF CATTLE.

Urea as a protein substitute. Interest in this aspect of nutrition continues to be shown particularly in America. It is reported that, for the best utilization of urea by growing calves, attention needs to be paid to the nature and amount of the carbohydrate in the ration. When maize molasses was added to a basal ration of timothy hay and urea, an active flora developed in the rumen and the urea was fairly well utilised but growth was subnormal, even with the addition of salt, bone meal and vitamin A. Normal growth was attained, however, when 0.3 per cent. of maize starch was added, thus indicating the need of a certain amount of more insoluble carbohydrate. In a test with Holstein cows, commenced in the 1st-2nd month of lactation and running for 210 days, increasing proportions of the protein concentrate of the ration were replaced by urea which was incorporated to the extent of 1.75 per cent. of the ration and increased to 3 per cent. for the last four months. The yield of milk was as high as in the control group and the percentages of fat and protein in the milk were not significantly different. There was no evidence of unpalatability or of digestive disturbance. Trials with fattening steers showed no evidence of any liver or kidney damage after feeding urea up to 2.3 per cent. of the ration for periods of 186-244 days. It is suggested that the harmful level for cattle may lie somewhere between 2.3 and 2.8 per cent. of the dry matter of the ration.

Contrary to the findings of the Jealott's Hill workers for cows and sheep, referred to in the last *Guide*, an experiment is reported from America (Ref. 1) where ammoniated beet pulp replaced ordinary beet pulp in a protein-deficient ration for calves, thereby increasing the crude protein content of the ration from 6.9 up to 12.4 or 17.0 per cent. The calves were fed over a period of 225 days and, whilst the animals on the basal ration quickly showed signs of protein deficiency, the animals receiving the ammoniated beet pulp gained an average of 1.6 lb. daily. The blood composition of these animals was normal and, at slaughter, the livers and kidneys were normal. The ration had no effect on colour or on flavour of the meat when roasted. Replacements of molasses by starch in the ration produced no beneficial effect. A control group receiving their supplementary protein in the form of heated soya bean meal gained 1.96 lb. daily.

Iodinated protein as a stimulant of milk production. The results obtained in this country and recorded in a preliminary report referred to in the last *Guide* find ample support from three series of trials carried out in America where either iodocasein or a thyroprotein (protamone) was fed to cows at different stages in lactation from three months onwards. In every case there was a marked increase in milk yield and percentage of fat in the milk and a concomitant fall in the body-weight of the cows which, as reported from one centre, was more than made good in the post-experimental period. A note of caution is sounded from one centre, where rises in body temperature were observed, as to the advisability of feeding such compounds during warm summer weather.

Turner and Reineke (Ref. 2) in a more detailed study found that such iodoproteins were inefficiently used by cattle and other ruminants. If the material was given orally in capsules the requirement was about halved as compared with administration by drenching. Subcutaneous injection reduced the requirement to about 5 per cent. of that needed by the latter process. Feeding by tube direct into the abomasum or true stomach had no more effect than with normal, oral feeding. Preliminary breakdown of the iodoprotein by hydrolysis showed that the resulting product, when given orally, was about twice as effective as the original iodoprotein. The results give no evidence of breakdown of the iodoproteins in the rumen but suggest that their relatively low utilization by ruminants may be due in part to the low digestibility of such materials in the ruminant alimentary tract.

Self-sufficiency on a dairy farm. A valuable and interesting record comes from the Hannah Dairy Research Institute (Ref. 3) of the cropping of their farm for the season 1940-41. During that year, no feeding stuffs were bought in and 18,500 gallons of milk, distributed equally between summer and winter, were produced on about 140 acres of which 134 acres were cultivated. From the findings of Leitch and Godden (Ref. 4) for the overall efficiency of milk production, taking into account the complete life cycle of the animal, it was concluded that, for every gallon of milk produced, the total protein equivalent to be fed to the herd was 2 lb. On this basis, a cropping system was evolved and, allowing for the acreage and estimated yield per acre for each crop (based on agricultural statistics) it was calculated that the total yield of milk should have been 20,540 gallons. When based on actual crop yields and allowing for crops sold off, the figure was 20,672 gallons. These figures make no allowance for the fact that the land supported, during the six winter months, over 6½ score of stock lambs from a hill farm.

In attaining these results, particular attention was paid to three points:—(1) the growing of increased acreage of arable crops, particularly of beans, soiling and catch crops and kale; (2) Improvement in the management and fertilizer treatment of the grassland; (3) Use of modern methods of grass conservation. The results obtained show up well in comparison with those for Scotland as a whole; for six dairy counties in 1938; for eighty selected dairy farms in 1937-38 and for Ayrshire in 1938. On the Institute farm, they had a greater herd of cattle per 100 acres, a greater herd of milking cows per 100 acres, more milk produced for sale per acre per year, and more milk produced for sale per cow per year than in any of the other areas.

Home-grown foods for milk production. In continuation of his studies on the use of home-grown foods for milk production, Blaxter (Ref. 5) has examined the effect of over and under feeding at the period of mid-lactation. Four groups of three cows were fed for three weeks at mid-lactation at three different levels of food intake. The control group (1) received a ration of bulky foods to cover maintenance and the production of the first 15 lb. of milk daily and concentrates in proportion to any milk in excess of this. Group II received the same ration as Group 1 *plus* 4 lb. of hay and 16 lb. mangolds; Group III as Group I *plus* 4 lb. of concentrates equal in feeding value to the extra hay and mangolds fed to Group II. Group IV received the same ration as Group 1 *minus* 4 lb. hay and 16 lb. mangolds. The

changes in milk yield were comparatively slight and only significant in Group IV. In this group a reduction of 2.6 lb. S.E. and 0.57 lb. P.E. *daily* only resulted in a reduction in the milk yield of 14 lb. *weekly*, or about one-fifth of what the reduction in the S.E. could cover. It is recommended that, where short-term food shortages occur in well-fed herds, economy should take place in the rations of cows in mid-lactation rather than of cows soon due to calve.

In a small scale test, it was found that there was no differential effect on milk yield or composition by spreading the bulky ration over 3, 4 or 5 meals daily. (In one case, 50 per cent. of the hay was kept for an 8 p.m. feed). There appeared to be no advantage in increasing the number of meals into which a ration is divided or in spreading the ration over a longer period of the day.

It was concluded that where small quantities of bulky foods of the highest quality are fed under conditions of " herd rationing " as opposed to " individual rationing," very large differences in the food consumption of individual cows is likely to arise to the detriment of the smaller, younger beasts. Only foods of the lowest feeding value should be fed at pasture or in yards or else the heifers and smaller cows should be segregated and their allowance of high-grade bulky foods given separately from that of the main herd.

Grazing habits. From America (Ref. 6) comes an account of the study of the grazing habits of Aberdeen-Angus and Hereford beef cows on pasture without supplementary feeding over continuous 24 hour periods during July, August and September. The pasture had a good growth of Kentucky bluegrass and wild white clover, and water was laid on. During a 24-hour period the cows spent from 7-8 hours only in grazing whatever the length of the herbage. Of this time, about 5 hours were actually employed in gathering herbage and the rest in walking short distances and in selecting areas to graze. About 60 per cent. of the grazing was performed by day, the average distance travelled being about 2 miles, and 40 per cent. by night, the average distance travelled being about ½ mile. The time spent in lying down was about 12 hours and in cudding 7 hours. The frequency of urination was 9 times and of defecation 12 times in the 24 hours, the amount of dung being about 46 lb. and covering an area of 8 sq. feet. The animals drank once only usually in the late afternoon and the calf sucked three times, each for about 15 min., at 8-hour intervals. With a dense sward, 4-5 inches high, giving about 4,500 lb. of green herbage to the acre, each cow was able to consume about 150 lb. of green herbage or 32 lb. of dry matter daily. As the amount of herbage, of the same height, decreased to 2,200 and 1,100 lb. per acre, the intake correspondingly decreased to 90 (20 of D.M.) and 45 lb. (10 of D.M.). When the pasture was 10 inches high and the yield 5,000 lb. per acre, the intake was 70 lb. of green herbage or 20 lb. of dry matter.

Calf rearing. Thompson (Ref. 7) reports a somewhat drastic method which has been carried out on a Cumberland farm whereby calves were reared with the minimum of milk. For the first three days, the calves received the beastings and for the next three days a quart of milk and a pint of warm water morning and evening. When the calf was 4 days old, a little dry food was placed in the bucket after the milk had been consumed and was offered at each meal until the calf began to eat it. The milk was then gradually replaced with warm water until at the end of a fortnight all the milk was replaced and ½ lb. of dry food was being consumed, the water being offered first followed by the food. Then hay was gradually introduced and, in the second month, the dry food was increased to 1½ lb. and about 1 lb. of roots was given. The dry food used in this case was crushed oats, bran, linseed, calf cake in the proportions of 3 : 1 : 1 : 1. The calves were not quite in the same condition as when given larger amounts of milk but they had a good bloom and progressed favourably as they grew older.

NUTRITION OF SHEEP.

Further evidence comes from Australia and South Africa in support of the relationship between nutrition and the incidence of pregnancy toxaemia. The former workers agree with the view that the disease is associated with, if not caused by, a disturbed carbohydrate metabolism due to the combination of a low calorie intake and a high demand on the ewe in late pregnancy. It can be prevented by providing a diet capable of maintaining live weight increase in the ewe during the last two months of pregnancy. The South African workers point out the harmful effect of a sudden change in the diet from full feeding to poor quality hay at the beginning of the fifth month of pregnancy. The condition was relieved somewhat by a daily supplement of ¼ lb. of molasses. This dosage was not adequate to cause normal lambing or to maintain weight but could not be exceeded without severe diarrhoea ensuing. They conclude that obesity is a potent factor in the causation of pregnancy disease. From America comes a report of a farm on which a condition resembling pregnancy toxaemia occurred in a flock of ewes on a ration of lucerne hay (low in carotene) and maize silage. It was apparently due to a vitamin A deficiency and the addition to the ration of daily individual doses of 30,000 I.U. of vitamin A promoted a disappearance of ketonuria and a clinical recovery in surviving cases which were not moribund.

In the Australian work, referred to above, it was found that a high level of pre-natal feeding, in one year such as to give a mean live weight increase during pregnancy of 30 lb. and in a second year of 20 lb., gave an increase in birth weight and growth rate of both single and twin lambs as compared with lambs from ewes on restricted grazing which just maintained the weight of the ewe. The workers doubt, however, whether the differences between the lambs were sufficient to make this high pre-natal feeding economic.

NUTRITION OF HORSES.

In their efforts to save cereals for human consumption, the Germans have been trying to find substitutes for oats in the ration of draught horses. From one centre it is reported that 66 lb. of raw potatoes, 4½ lb. of sweet lupin meal and 9 lb. each of hay and chaff sufficed to maintain horses, weighing 1,300-1,400 lb., in perfect health and good appetite under the most strenuous working conditions. With horses on light work, the fodder and sweet lupin meal could be reduced. It is desirable to make the change over from oats to potatoes and lupin meal very gradually and to use good quality, well washed potatoes chopped small and fed in weighed quantities at regular intervals. In place of the raw potatoes, the pulp which remains after the manufacture of starch from potatoes, if pressed and dried, can be used. A pound of such pulp replaced 2½ lb. of raw potatoes.

From Russia comes a report of an investigation of 13 studs in which an epizootic occurrence of abortion was found to be due, in the majority of cases, to defective diet and that it only assumed an infectious aspect later due to the low resistance of stabled animals. The animals were stabled and had been changed over too rapidly from grazing to stall feeding with fodder of low nutritive value. It was found that the feeding of sprouted cereals resulted in a decrease of all kinds of abortion to an insignificant level. The best results were obtained by feeding a supplement of ¾-1½ oz. of bone meal and 7 oz. of sprouted wheat, or sprouted grain alone and 3-4 hours' exercise daily. Gestation then ran a normal course, parturition was normal and strong, viable foals were born and the mares came into heat quickly after foaling

NUTRITION OF THE PIG.

Palm kernel meal for bacon pigs. Dissatisfaction has from time to time been expressed by pig feeders with regard to the supply of palm kernel meal against coupons in the cereal category on account of its low palatability. Woodman and Evans (Ref. 8) have accordingly

investigated its use. Digestibility trials with pigs of 130-140 lb. live weight showed that 100 lb. of dry matter in palm kernel meal contain 65.8 lb. of digestible organic matter as compared with 65.4 lb. in farm ground oats or 64.5 lb. in fine bran (the fine wheat feed resulting from milling at the 85 per cent. extraction level).

Feeding trials showed that, whilst the meal is too fibrous for inclusion in more than very small amounts in the ration of newly weaned pigs, from 50 lb. live weight onwards it may be introduced and gradually increased to 15-20 per cent. of the total ration and, from 100 lb. live weight, up to about 33 per cent. and then retained at this level till slaughter. In times of shortage of other feeds, it may be raised to as much as 50 per cent. at 150 lb. live weight provided the other ingredients of the ration are palatable, but there may follow a slight depression of appetite and the pigs may be, at times, rather "loose." There should be no difficulty in maintaining a daily live weight increase of 1 lb. to slaughter or in producing a satisfactory finish. In introducing the meal into the ration or when increasing the amount already present, such changes should be made gradually.

It must be remembered that palm kernel meal contains only about 12 per cent. of digestible crude protein and must not be regarded as a protein-rich food. Its use does not preclude the necessity for feeding some protein-rich food, *e.g.*, white fish meal, to make provision for the protein requirements of bacon pigs.

Incidentally, in these trials, the control pigs were fed from 150 lb. to slaughter weight, owing to war-time conditions, on a ration of 85 per cent. fine bran or fine millers' offals, 5 per cent. lucerne meal and 10 per cent. extracted, decorticated ground nut meal, with 2 per cent. of a mineral mixture added, and only gained 1.07 lb. per day with a mean requirement of 6.07 lb. of meal per lb. of live weight gain. This indicates the poor results that may be expected from pigs on war-time rations containing very high proportions of fine bran or fine millers' offals.

Sources of protein. Two papers by Braude *et al* (Ref. 9) have appeared recently in which attention is drawn to the fact that, when yeast at levels up to 20 per cent. is used as a source of protein in rations for growing pigs, rickets is liable to develop. Addition of cod liver oil or calciferol (vitamin D) prevented the occurrence of the disease and larger doses of calciferol (3780 I.U. per day) cured animals that had developed severe rickets on the yeast diet. The addition of 4 per cent. of chalk also gave distinct improvement but not complete protection and it does not appear that the rachitogenic effect of the diet is due solely to the high content of available phosphorus.

Feeding trials with potatoes show that the value of potato protein, when fed as the sole source of protein or when supplemented with 1-6 per cent. of casein, was consistently lower than that of barley protein fed under similar conditions. Other work has shown that dried potatoes, as flakes or slices, can be included to the extent of 40-50 per cent. in rations for fattening pigs provided due attention is paid to balancing the ration as regards protein and minerals. In this respect, the flakes appeared to be slightly superior to the slices.

Alleged toxicity of cod liver oil for pigs. Trials with four different samples of cod liver oil, one of dog-fish liver oil and one of sperm oil, fed to pigs between the ages of 20-142 days in amounts increasing from one-sixth ounce up to 2 oz. at weaning and thereafter 4 oz. daily, failed to produce any clinical or *post-mortem* evidence of toxicity such as has been reported for herbivora (Ref. 10). There was slight retardation of growth between weaning and 80 days with three of the samples of cod liver oil but this was thought to be due to the mechanical laxative effect of an excessive intake of oil rather than to a specific growth retarding factor. These results confirm earlier findings by the same authors (Ref. 11) that genuine cod liver oil or marine oils are not primary etiological factors in the causation of toxic liver dystrophy even when administered to pigs in excessive amount.

POULTRY NUTRITION.

Soya beans as a source of protein. Indian workers report that soya bean meal was not such a good source of protein supplement to a basal ration of wheat bran, yellow maize and ground oats as was separated milk for week-old chicks even when ground limestone and green food were given in both cases. There did not appear to be any difference in nutritive value between extracted and heat-extracted meal. American workers, however, report that if soya bean meal is to be used as the sole source of protein for chicks, it requires to have received suitable heat treatment during its manufacture. Such a diet was improved by the addition of 3 per cent. of meat scraps and 5 per cent. of dried skim milk. Yeast protein and plant proteins were found not to be suitable supplements for soya bean meal. Other workers, however, found that a combination of sesame and soya bean meals gave markedly better results as the sole source of protein for 10-day old chicks than either meal separately. Sesame meal alone gave very poor results.

For laying pullets a ration containing 9 per cent. of soya bean meal and 9 per cent. of fish meal or one containing 9.5 per cent. of soya bean meal and 9.5 per cent. of meat scrap gave practically as good results as a similar ration with 15 per cent. of fish meal, when measured by egg production, food consumption or food consumption per dozen eggs. All groups showed satisfactory gains in body weight and little difference in viability. In another case where ½, ¾ or all of the supplementary protein was supplied as soya bean meal and the remainder, if any, as meat scraps, there was no difference in egg production or hatchability between the three level of soya bean meal feeding, although body weight tended to improve where some animal protein was given.

Level and type of protein. The pullets which, as reported in the last *Guide*, were reared on different levels of protein of animal and vegetable origin were continued for a one-year laying period on similar rations (Ref. 12). The low level of protein (12.5 per cent.) failed to give satisfactory results for egg production, egg weight, days to first egg, or body weight of the birds. The highest protein level (17 per cent.) was superior to the medium level (14.5 per cent.) only in egg size and days to first egg. Feed efficiency was greatest at the medium level. The highest protein level appeared to be a greater predisposing factor towards mortality than the other protein levels. The general findings were that, on the basis of feed cost, the medium level of protein was more economical than the low or high levels; that animal protein was better than vegetable protein even although the latter was supplemented with 2.5 per cent. of dried buttermilk powder, and that birds kept in battery cages did better, in all respects, than those kept in laying pens. The level of the protein had no effect on hatchability but, in this respect, animal protein was better than vegetable protein.

Unlike powdered swine hoofs (see last *Guide*), hoof and horn meal does not seem so satisfactory a source of protein for poultry. It is an inadequate substitute for fish meal and, in the absence of the latter, cannot adequately replace meat meal. It did not show any supplemental effect with any of the vegetable proteins with which it was tried and was, in fact, rather inferior to them.

Kitchen waste. Two types of this material have been tested for growing chicks (Ref. 13). Cockerels were successfully reared from 1 to 9 weeks of age on a ration eventually containing 50 per cent. by weight (25 per cent. on a dry matter basis) of standard, semi-dried, processed food waste. Capons were also fed from 9 to 36 weeks of age on a ration containing up to 96 per cent. of the food waste, but better results were obtained if a small amount of meat meal was included in the ration. Pullets were reared satisfactorily on a ration containing 65 per cent. of the food waste, but did not do so well when 80 per cent. was used.

A fortified dried food waste, containing 25 per cent. of crude protein, was fed at a 30 per cent. level with 70 per cent. of National Growers' mash to young chicks from 10 weeks

onwards without any harmful effect on health but gave a slightly lower live weight at 32 weeks than an all-mash ration. The safe upper level for its use seemed to be 30 per cent. but even at that level the food cost was higher than for the all-mash group.

Further evidence has been produced that the maximum level at which semi-dried town kitchen waste can be usefully incorporated in a ration for laying birds is one which provides not more than two-thirds of the dry matter of the ration. There is evidence that the feeding of such a bulky ration to the male may be partly responsible for a lowering of fertility in the eggs.

Restricted feeding. The reduction of food intake of growing pullets to 90 and 80 per cent. respectively of that of a full-fed control group showed that the two restricted groups at the end of rearing did not differ significantly from each other in body weight but were 14-16 per cent. lighter than the control birds (Ref. 14). For the laying period, all birds were fed to appetite and there was no marked difference between the three groups as regards food consumption, egg production or body weight at the end of the laying peri d. Other birds were kept on their restricted rations during the laying period. Those receiving 90 per cent. of the control food intake maintained their egg production but lost weight. The group receiving 80 per cent. food intake had both their egg production and body weight adversely affected. Moderate food restriction may be practised as a war-time expedient with consequent saving in food but it should not be pushed too far.

Milling offals. In the last *Guide* an account was given of the work of Woodman and Evans with reference to war-time milling offals and their nutritive value for sheep and pigs. Halnan (Ref. 15) has now reported along the same lines for poultry. Up to 1942, the fine bran was a better product than pre-war bran and the coarse bran a poorer product. The introduction of barley into the grist in 1943 lowered the availability of the fine bran by just over 25 per cent. It would appear that, in the two types of 1942 bran, only the starch present was utilisable but that, in the 1943 bran with barley in the grist, even all the starch was not fully digested or utilised. Fine grinding of the coarse bran had no appreciable effect on its availability for poultry.

Potato products. Halnan (Ref. 16) finds that raw potatoes, though readily consumed when mixed with other foods, were not readily utilised whereas boiled potatoes were. The energy of 1 lb. of cooked potatoes was equal to that of 5 lb. of raw potatoes. The food value of processed, dried potatoes depended on the nature of the heat treatment. Thus low temperature dried potato shreds had the lowest digestibility and availability of the three forms tried. Potato slices dried in a sugar factory approximated in nutritive value on a dry matter basis to well cooked potatoes. The results emphasise the desirability of proper cooking of potatoes intended for poultry feeding.

GENERAL.

Bracken. Results recently reported from Jealott's Hill (Ref. 17) indicate that the ensiling of bracken is unlikely to prove profitable. Bracken cut in June was ensiled with and without molasses. Over-heated silage, without molasses, was moderately palatable but its digestibility was low. Silage made at lower temperatures, with or without molasses, was unpalatable and, in some cases, absolutely refused by sheep. Its digestibility, though slightly higher than that of overheated silage, was still low. Ensiling caused, in either case, a serious lowering of the digestibility of the protein.

Pea-canning by-products. The materials examined by Woodman and Evans (Ref. 18) were green pea pods, pea pod meal, pea pod silage and molassed silage from pea haulms with pods. All the materials contained from 12.8-15.0 per cent. of crude protein, 1.5-2.3 per cent. CaO and 0.43-0.66 per cent. P_2O_5 on a dry matter basis.

Pea pods yield an excellent silage providing they are tightly trampled and a means for

draining off the effluent is supplied. Molasses need not be added. The product is much relished by sheep and cattle. Digestibility trials with sheep show that 100 lb., containing 27.5 lb. of dry matter, give 15.9 lb. S.E. and 2.3 lb. digestible crude protein. Pea haulms and pods, when ensiled with molasses, gave a satisfactory silage which was also readily eaten by cattle and sheep. Its composition varied somewhat in passing down the silo, but, on an average, it contained :— dry matter 23.6, S.E. 11.6 and digestible crude protein 2.0 per cent. Pea pod meal had a low palatability when fed alone and gave 59.6 per cent. S.E. but only 3.4 per cent. P.E. on a dry matter basis.

Digestibility trials with 2 bacon pigs of about 160 lb. live weight showed that the pigs, after thoroughly masticating steamed pea pods, rejected relatively large masses of chewed, fibrous residue. Pockets of such material were discovered in the dung suggesting that constipation, with possible risk of stoppage, might result from the indiscriminate feeding of pea pods to pigs.

Swill. Woodman and Evans (Ref. 19) have extended their investigations into the character and composition of collected urban swill as affected by seasonal variation. Summer swill was characterised by large quantities of pea pods with cabbage leaves and stalks and bread. Its dry matter had a higher content of protein and calcium and lower content of N-free extractives than winter swill which was characterised by large quantities of potato peelings with cabbage leaves and other vegetable residues. Pigs made more efficient use of the swill than did sheep. One ton of fresh winter swill (70.2 per cent. moisture) would on an average, contain as much digestible organic matter as 0.34 ton of a mixture of barley and coarse middlings (2 : 1). One ton of fresh summer swill (69.9 per cent. moisture) would be equal in digestible organic matter content to 0.35 ton of coarse middlings.

Minerals in Pasture. An interesting publication bringing up-to-date our state of knowledge on this subject, has been published by the Imperial Bureau of Animal Nutrition (Ref. 20). It deals mainly with the influence of so-called " trace " elements on the health of farm animals and shows how investigations in the last 10-20 years have helped to solve many problems of disease concerned with the grazing animal.

W. GODDEN.

ROWETT RESEARCH INSTITUTE,
BUCKSBURN, ABERDEENSHIRE.

References

1. MILLAR, H. C., *Jour. Dairy Sci.*, XXVII, p. 225.
2. TURNER, C. W. and REINEKE, E. P. *Jour. Dairy Sci.*, XXVII, p. 642.
3. WRIGHT, N. C., FOWLER, A. B. and THOM, C. L., *Trans. Highl. Agric. Soc.*, LV, p. 54.
4. LEITCH, I. and GODDEN, W., *Imp. Bur. Anim. Nutr.*, *Tech. Commun.*, No. 14, April 1941.
5. BLAXTER, K. L. *Jour. Agric. Sci.*, XXXIV., pp. 213, 217.
6. JOHNSTONE-WALLACE, D. B. and KENNEDY, K. *Jour. Agric. Sci.*, XXXIV, p. 190.
7. THOMPSON, C. K. *Jour. Min. Agric.*, LI, p. 354.
8. WOODMAN, H. E. and EVANS, R. E. *Jour. Agric. Sci.*, XXXV, p. 44.
9. BRAUDE, R. KON, S. K. and WHITE, E. G. *Jour. Comp. Pathol.*, LIII, p. 161 ; LIV, p. 88.
10. SCORGIE, N. J. and MILLER, W. C. *Empire Jour. Exp. Agric.*, XII, p. 74.
11. SCORGIE, N. J. and MILLER, W. C. *Empire Jour. Exp. Agric.*, VII, p. 357.
12. GUTTERIDGE, H. S., O'NEILL, J. B. and PRATT, J. M. *Scientific Agric.*, XXIV, p. 240.
13. TEMPERTON, H. and DUDLEY, J. F. *Harper Adams Utility Poultry Jour.*, XXIX, pp. 1, 51, 55.
14. TEMPERTON, H. and DUDLEY, J. F. *Harper Adams Utility Poultry Jour.*, XXIX, pp 15, 19, 24.
15. HALNAN, E. T. *Jour. Agric., Sci.*, XXXIV, p. 133.
16. HALNAN, E. T. *Jour. Agric. Sci.*, XXXIV, p. 139.
17. FERGUSON, W. S. and NEAVE, O. *Jour. Agric. Sci.*, XXXIV, p. 172.
18. WOODMAN, H. E. and EVANS, R. E. *Jour. Agric. Sci.*, XXXIV, p. 155.
19. WOODMAN, H. E. and EVANS, R. E. *Jour. Agric. Sci.*, XXXIV, p. 110.
20. RUSSELL, F. C. *Imp. Bur. Anim. Nutr.*, *Tech. Commun.*, No. 15, May 1944.

FARM IMPLEMENTS AND MACHINERY

GENERAL FARM MECHANIZATION.

In last year's *Guide* reference was made to some trade estimates of U.S.A machinery requirements for agriculture in the first post-war year. Due to wartime restrictions on manufacture there was likely to be a stored-up demand, equal in the case of tractors and more modern types of equipment to at least twice the normal unrestricted annual output. Since then there has come to hand a very comprehensive statistical review of the position from the American farmer's point of view. This is a U.S.D.A. report which gives, for each State separately and for each of the main implements, the estimated total numbers on farms on January 1st, 1942 and 1945, together with estimates of age, size and work done in 1941 (Ref. 1). In spite of the manufacturing restrictions referred to, the U.S. tractor population shows a 12 per cent. increase over the three-year period and, during 1944, passed the two million mark. The report points out that some harvest appliances like corn pickers, combines and pick-up balers constituted a larger share of total production during wartime than in the immediately preceding years so that, in their case, the proportionate increases have been higher. The outstanding example is the pick-up baler whose numbers have increased by 67 per cent. during the period referred to. In general, it is pointed out that manufacturing limitations, acute shortage of skilled labour, and large cash farm incomes have together resulted in a greatly increased demand for equipment, and in markedly increased prices for second-hand machines. As a result, the figures given for numbers on farms include an appreciable proportion that, according to normal standards, would have passed their period of usefulness. The report estimates, for example, that something like 150,000 tractors are in this condition. These facts have been outlined not because they are at all surprising—indeed, having regard to our smaller scale of things and more recent adoption of wider mechanization, much the same state of affairs probably exists here—but because they emphasise one very unexpected feature in the American figures. This is the general and quite steady decrease in the number of binders, both tractor and horse drawn. For example, in Michigan—where farming is small-scale, unspecialized, and not particularly highly mechanized—there were estimated to be 62,000 horse-binders, 8,500 tractor binders, and 9,200 combines on farms at the beginning of 1945. Over the previous three years binder numbers had fallen by some 10 per cent. for horse-drawn types, and by 6 per cent. for tractor types, while combine numbers had increased by over 50 per cent. Further, it was estimated that in 1941—practically speaking the last pre-war year in America—the average horse or tractor binder in Michigan did only 26 hours of work a year while the average combine did over a hundred hours. Additional emphasis is provided by information given in another paper (Ref. 2) . a study of methods practised on a group of 46 Michigan farms each of which grew on average not more than 50 acres of grain crops. This showed that over three-quarters of the farmers used combines—either their own or a neighbour's. As has been said this tendency is quite general : it is to be seen equally in the returns for the Dakotas which are

concerned mainly with wheat growing, or in those for Iowa where (subject to the over-riding importance of maize) oats is the main grain crop. It would seem that, regardless of almost any other consideration, the sheer direct labour-saving appeal of combines is irresistible, and that the tractor binder is becoming obsolete almost before it had challenged its horse-drawn counterpart. It is probable that the same tendency would be observable with other crops: that the spectacular increase in pick-up balers already mentioned would be offset by a general decline in hayloaders (for which no statistics are given). In the same way the corn (*i.e.* maize) picker is probably ousting the corn binder.

The second paper mentioned above (Ref. 2), is a study of farm labour efficiency by the Farm Management Section of the Michigan State College. It analyses and compares management data from two groups of farms one of which shows a high degree—and the other a low degree—of overall labour efficiency. Efficiency is measured in terms of what are called Production Man Work Units. A work unit is what an efficient man should do in a 10-hour day, and the number of units corresponding to each kind of product is laid down on a fixed, and rather arbitrary scale. Thus a dairy cow is reckoned as 15 P.M.W. units, an acre of maize as 3 units, and an acre of small grain (wheat, barley, oats, etc.) as 1 unit. The overall efficiency measure for the farm is the number of P.M.W. units scored per man employed. Presumably the 15 units corresponding to a dairy cow include the growing of the foodstuffs which she eats; so that if, as on many of our pre-war dairy farms, much of the feeding stuff was purchased, the number of units would need to be reduced. The two groups of farms referred to averaged respectively (in 1943) 370 and 185 P.M.W. units per man employed. The analysis showed that better choice, or better use, of machinery, was one factor contributing to the comparative success of the high-efficiency group: the farms concerned had rather more modern tractors, rather wider cultivating implements, and made more use of labour-saving appliances at harvest time. But the overall conclusion was that efficiency depends more on the farmer and the farm than on direct labour-saving by machine or method. It is interesting to note that farm layout—including field size and shape—is counted as a highly important factor. This is the more striking since all American farms tend to be compact and rectangular in shape by comparison with ours. Such awkwardnesses as exist are those arising from a stream breaking up the general shape, or from a local patch of woodlot or swamp within the farm boundary. If these are sufficient to affect efficiency, how much more marked must be the influence of some of our farm layouts: for example, those discussed in a recent report from Oxford (Ref. 3).

Another subject which is attracting a good deal of attention in the U.S.A. is the influence of farm buildings on mechanization and labour saving. In one of a number of papers published on this topic during the year under review, Reynolds (Ref. 4) argues that general farm mechanization is ahead of the functional development of farm structures. Practically every farm product is either used in and around the farmstead, or is at least finally handled there; and in America, as in all too many instances here, they seem to have got to the stage where the advantages of further mechanization in the field are liable to be offset by worse bottlenecks in the yard. Reynolds claims that improved and better laid-out buildings could bring all kinds of direct benefits by eliminating unproductive work, decreasing machinery depreciation, reducing crop losses due to improper handling and storage, and so on—and no one in this country is likely to disagree with him. Incidentally, it is interesting to note that included in the types of building that are being severely criticised in America are some which visitors from this country have upheld in favourable comparison with our own. There is the two-storey dairy barn, for example, with all hay and feeding stuffs stored immediately above the cows so that the force of gravity can be used to aid human effort at feeding time. In the Middle West, however, where barns of this kind are almost universal, there is serious complaint about the labour required to put the hay into these buildings, and the resulting bottleneck which arises at haymaking time.

The American Society of Agricultural Engineers has set up a new Committee on Post-War Objectives and, to judge from a preliminary letter sent by the Chairman to the members (Ref. 5), this, too, will take a very wide view of what agricultural mechanization may mean. In posing the question, " What is the future of mechanization in agriculture ?" this letter points out that some people think the farm is destined to become a commercial unit based entirely on costs of production and margin of profit. In this view, farms would grow larger, and the number of persons engaged smaller, until some ten per cent. of the population would provide all the food and fibre required for the whole. Hazen, the Chairman in question, has no doubt that with the aid of modern machinery this would be entirely feasible, although he obviously doubts the wisdom of anything so extreme. " But," he goes on to say, " I for one am formally committed to the reduction of manual toil—I want fingertip control to replace main might and awkwardness in every phase of rural living. If I am to live on a small plot of ground with one cow, sow and hen, I do not care to tote the hay and silage with a fork, shuck the corn by hand, and spread the stable manure from a wheel-barrow." This would entail small machinery of every kind and a list is given of some which might be considered to start with. Among these are . a set of motorised farm implements powered by a motor which could be shifted from one to another (with the aid of a simple hoist) in 15 seconds ; a two-way plough which is in front of the operator ; a fertilizer attachment which can operate from plough, mower or combine ; and a levelling suspension for tillage implements working on steep hillsides Another paper on agricultural engineering opportunities particularly stresses the importance of better education at all levels from University to the short course for farm workers (Ref. 6).

Two papers which discuss future trends of development from the point of view of this country should also be mentioned. In the first, Davies (Ref. 7) deals with some of the mechanical problems of harvesting, and ranges over a wide field from grain crops to potatoes and roots. In the one direction he makes out a good case for a stooking machine, and for an auxiliary-engined binder ; while, in the other, he sketches some of the ideas - fanciful-looking at present but with at least a touch of practical possibility behind them —which may one day enable such problems as the separation of potatoes from stones to be solved in a field machine. The other paper by Culpin (Ref. 8) deals with machinery for crop production. Among other things he questions, on different grounds, the present popularity of general-purpose plough breasts, zig-zag harrows and tractor rolls. In particular, he suggests that the broken work of a digger plough will very often lie drier in winter, and weather down better in spring, than the unbroken furrow-slices which we still favour by tradition.

Later in this article, several references are made to a new publication, " Agricultural Engineering Record." This is being issued quarterly by the National Institute of Agricultural Engineering, and will provide a welcome vehicle for the direct publication of research results in agricultural engineering. A similar publication under the same title was started at Oxford in 1940, but had to be discontinued owing to the war

TRACTORS.

A bulletin from the University of Nebraska summarizes the operation of the well-known Nebraska Tractor Tests from their inception in 1920 up to the end of 1941 (Ref. 9). Since the latter date no new tractor models have been put on the market so that no further tests have been carried out under the scheme. The bulletin gives in tabular form test data for the 96 models that are still in production out of the total of 368 so far tested. The report on the oldest of these was issued in 1930. The bulletin also gives a well-illustrated account of the way the tests are carried out and of the apparatus used. As may not be generally remembered now, these tests arose from the Nebraska Tractor Law, which became effective in 1919, and was enacted to " encourage the manufacture and sale of improved types of

tractors and to contribute to a more successful use of the tractor for farming." The Law makes two main provisions. First it forbids the sale of any model or type of liquid fuel tractor engine in the State until it has been "tested and passed upon. . . .by a board of three competent engineers. . . . under the control of the State University management." Secondly, it enables the State Railway Commission to deny to liquid fuel tractor companies the right to do business in the State if it is found on the complaint of two or more bona-fide customers to fail to maintain "an adequate service station with full supply of replacement parts within the State and within reasonable shipping distance of the said customers."

Another technical bulletin published during the year presents at a very opportune moment research results which have, so to speak, been in cold storage during wartime (Ref. 10). This is an N.I.A.E. bulletin giving in some detail the results of researches on pneumatic tractor tyre performance which were carried out at Oxford in 1939-40. When the war began to curtail supplies of rubber, pneumatic tyres were well on the way to becoming universal in the U.S.A.—they were fitted to something over 95 per cent. of all new wheel tractors sold there over the years 1939-41. In this country, too, pneumatic tyres were obviously in the ascendant though in less marked fashion; and, because of their general convenience in our mixed farming, there is no doubt that the tendency will continue whenever the supply position allows. At the same time difficulties have been experienced: in comparison with American conditions our soils are heavier, more of our work is done at low speeds, and more is done under wet conditions. When these factors combine—as may happen in late Autumn cultivations for example—pneumatic tyres are liable to lose by imperfect adhesion more than they gain through lower rolling resistance and the general convenience already referred to. The results of the Oxford researches will enable tyre and tractor manufacturers to improve practical performance by providing wheel equipment more appropriate to the particular tractors concerned. They show that, of the factors affecting pneumatic tyre performance, overall diameter and back-axle weight are more important than any others This does not mean that tractors should necessarily be made heavier. But there is all-round advantage in fitting the largest diameter wheels that are consistent with general design requirements, while, for a given wheel size, there is a limited range of ratio of pull to back-axle weight over which reasonably high tractive efficiency can be expected under ordinary conditions. If the tractor is geared to give ratios within these limits, its performance will be satisfactory. If not, added weight is the only practicable solution. Compared with the factors mentioned, tyre sections and pressure are relatively unimportant. The same is true, with one reservation, of tread pattern, so that farmers should not place too much confidence in claims that this or that arrangement of bars or ribs will make much direct difference to wheel grip. The reservation is that, probably due to greater flexibility, some patterns are more successful in keeping clean than others. Two reviews of this research work may be of interest to those who find the original publication too technical to be easily followed. The first by Hine (Ref. 11) is written mainly from the standpoint of the farmer-user and draws attention to a number of points of practical performance that it is worth while to understand. The other is more technical and will be of more interest to designers (Ref. 12). There may also be mentioned a general paper by the present writer, one section of which sketches the development over the pre-war years of tractor testing and research in this country, and mentions some of the directions in which further work is being carried on at present (Ref. 13). One important problem, and a very difficult one, is to provide the "missing link" which will enable horses to be dispensed with entirely. A great deal has been accomplished by small light tractors with complete sets of directly-attached implements although even with these there is, on the very small farm, the final difficulty which arises from having all the power in one unit. A parallel development is the new type of motor cultivator of which several models are now in limited production (Refs. 14 and 15).

CULTIVATIONS.

There has once more been a public discussion of the much-vexed question of whether intensive cultivations are, or are not, worth while, the main protagonists on this occasion being a Scottish farmer and a research worker (Ref. 16). As might be expected, the farmer was out to defend the great amount of work he and his neighbours have been accustomed to put into the job of making a seed bed; while the research worker was inclined to argue that "agricultural crops are far more sensitive to weeds than to tilth." In one sense, of course, this argument begs the question, for in our climate to cultivate often enough to keep weeds under proper control generally means cultivating as often as available time and power allow. The main discussion, however, centred round depth of cultivation. It was pointed out on the one hand that not even a deep-ploughing enthusiast would advocate a sudden change of method. Cultivation depth should be increased gradually year by year and sometimes it might be advisable to subsoil first—*i.e.* to break up the raw subsoil thoroughly a year or so before attempting to incorporate it into the general cultivated layer. On the other hand, the fact that it was possible to grow crops without using a plough at all had been amply demonstrated by the changed methods which were being used successfully in some overseas areas. It was not of course suggested that any such methods would be practicable in our very different conditions; yet to follow traditional methods too slavishly was obviously wrong. One point which came out in the discussion was in line with Culpin's observations as already recorded. This was the usefulness of the digger type of plough body as a means of making a very close approximation to a seed bed in one operation.

A paper by Cameron Brown discusses the application of electricity to field operations from a rather novel point of view (Ref. 17). He is concerned not so much to claim any direct advantage for field work done by electricity as to demonstrate that it can be done; because if it were done on even a small part of our land the whole aspect of Rural Electrification would be changed. The paper is certainly interesting from the historical standpoint since it discloses a great deal of experimentation, and even of practical application, of which most people will have been quite unaware. There seem to be three main areas in which active progress has been made: France, Algeria and New Zealand. In the Dominion at least five "electrical tractors" were in regular use by 1940, and more than one farm had been fully equipped so that they could be used with nearly as much freedom of manoeuvre as an ordinary tractor.

In the last two numbers of the *Guide* the gradual development of the segmenting process for sugar beet seed has been traced. This year the full results of the first properly conducted trials to be carried out in this country have been reported (Ref. 18). It will be remembered that the use of segmented seed aims at saving, or even eliminating, singling labour and at facilitating inter-row cultivations. The main purpose of these first trials was to see whether the seed could be drilled satisfactorily and whether the resulting "braird" would give a sufficient proportion of single plants; but some estimates of relative singling labour were also made. Due to most unfavourable germinating conditions, the results from some of the plots drilled with very low seed rates were not too satisfactory. But plots drilled with up to 12 lb. per acre—*i.e.* not very much less seed than is normally used—gave very satisfactory results from the plant population standpoint; and, rather surprisingly, effected quite a considerable labour economy. In two trials, for example, the 12 lb. per acre segmented seed plots needed only 18 and 13 man hours of singling labour per acre compared, respectively, with 30 and 18 man hours for ordinary seed at normal seed rates. In a more normal season—or as the technique of segmenting and grading the seed is improved—it should be possible to lower seed rates without materially affecting plant population and much greater economies should be possible. Additional and more extensive trials have been undertaken and, to judge from preliminary indications, further progress is well on the way.

HAY AND SILAGE MACHINERY.

Two machines which were given a brief mention under this heading in last year's *Guide*—the one-man pick-up baler and the silage " combine "—have now reached practical fruition in the U.S.A. in the sense that several alternative models are coming on to the market. In addition there is a rapidly-growing interest in what is called " mow drying," *i.e.* the artificial drying of hay in the barn with cold or only slightly heated air. Between them these developments seem likely to effect something like a major revolution in American methods of making both hay and silage, although, particularly in the case of hay, there is a considerable conflict of ideas so that the exact outcome is uncertain. The machines themselves are straightforward enough. The typical one-man baler is a more compact version of the " slicing " type of pick-up baler to which we have become accustomed over the last few years, with the addition of an ingenious adaptation of much the same needles and knotter as are used in the everyday binder. It uses a specially strong twine, ties the bales with two bands automatically and is said to have a capacity in straightforward work of 3 or 4 bales per minute. There is also the quite unorthodox " roll-up " baler mentioned last year which will make a very tight and weatherproof cylindrical bale with almost any kind of material. Machines of both types have been described with illustrations in a recent article (Ref. 19).

In addition there are at least two wire-tying models of the usual rectangular bale type. One is fully-automatic but needs a specially prepared kind of wire : while the other cuts and places ordinary baling wire but needs the services of a second man to take care of the final fastening. Actually it is rather doubtful whether any of these machines—except possibly the " roll-up " will ever be strictly one-man in practical operation. For the mechanism is a very intricate one to work completely unattended in all the hazards of an everyday hayfield. Moreover if there was any hitch in the knotting mechanism there would be two untied bales in the chamber and one on the ground before even the most alert tractor driver could notice anything wrong. Generally, one feels, it will be advisable to have at least a boy on the machine, but even so, the saving of labour in comparison with present methods will be considerable.

The silage harvester (or " combine ") will cut the crop, chop it, and blow or elevate the chopped material either into a trailer hauled behind the outfit or into a truck running alongside. One or two machines of this type have already been seen over here but the new models are much more compact and handy, and are likely to be less expensive. In America these machines will have two alternative fittings : a pick-up attachment for hay or partly wilted silage crops and a corn reaper attachment for silage maize. With either, the material will be chopped and blown or elevated direct into the vehicle as before. It seems likely that the corn reaper attachment might be so adapted as to deal with kale.

Both the hay-chopping attachment just mentioned, and the general idea of mow drying, arise from the particular circumstances in which hay is made over a considerable area in the States. Throughout the Middle West and in the North Eastern States hay is almost universally stored in barns—actually in the top part of the two-storey barns mentioned in an earlier section of this article. The hay is loaded in the field much as we do it but lifting it into the barn and packing it away takes a good deal more labour than we should use in making a stack. Moreover hay which is to be put into a confined space (in a wooden structure) needs to be very thoroughly dried and since most of it consists of lucerne or some similar " stemmy " crop, there is a very considerable loss of valuable leaf parts if all the drying is done in the field. The idea behind chopping the hay is simply to make it " fluid " so that it can be blown into the barn with a consequent saving of labour. The idea of finishing off the drying by blowing cold or slightly heated air through a system of simple ducts prearranged on the barn floor, arose originally from the desire to get the hay in before the leaf parts had become brittle. Today, however, enthusiasm has rather run riot and attempts

are being made to dry almost fresh-cut material in this way. One recent paper (Ref. 20) gives a straightforward account of an experiment which may be said to have been reasonably successful: but the blowing process went on intermittently from June 14th to July 17th which would make the whole thing a rather long-drawn-out affair by our standards. Another paper (Ref. 21) deals with a more elaborate series of experiments which aimed at getting more exact information on a number of points including the optimum rate of air flow; effect of original moisture content on final quality; duration of blowing and so on. The results seem to have been too variable to lead to any very definite conclusions except possibly that the process is not a very good one for anything like really green grass: with very few exceptions all the samples put in at over about 50 per cent. moisture content came out finally in a more or less mouldy condition. Yet another paper, to which is appended a quite interesting discussion, deals with the use of heated air, the main difference from artificial grass drying as we know it being that, in almost all the American instances, the material is hay not short grass – and is dried where it is to be finally stored (Ref. 22).

It will be interesting to see whether mow drying is any more successful in the long run than our stack-drying experiments of 20 years ago. It will also be interesting to see how, if at all, the development is affected by the introduction of the one-man baler. For, according to our ideas, the latter machine should be capable of accomplishing the original objects of the mow drying idea: saving of carrying labour, and ability to put up the hay in rather greener condition. Some American experiments on hay baling have been reported by Schroeder and Ackerman (Ref. 23). Their paper gives a good deal of information as to how one-man baling works out in the field, together with some preliminary research results on the effect of baling at different densities and moisture contents. The results are generally in accord with those reported, as recalled last year, by Cashmore, except that a rather lower "safe" maximum moisture content seems to have been indicated. In the American work the bales were taken straight into barn storage, while the tendency here is to leave the bales in the field for the time being, and this may have affected the drying-out process. In this connexion, an interesting feature is the considerable labour team required to move and store bales as fast as they are made: with a haulage distance of about a mile the whole job needed 7 or 8 men or, at the normal rate of working, about 2 man hours per ton of baled hay. Another paper deals specifically with the problem of handling bales from field to storage (Ref. 24).

In silage making, too, the main difficulty is to maintain a smooth flow of material all the way from field to silo; and the first immediate result of the new silage harvesters will probably be to make one end of it—avoiding a bottleneck at the silo—all the more difficult. No considered account of silage making with these new machines has yet been written but it seems, from casual reports, that the problem of unloading and feeding the blower fast enough has still to be overcome. It will be much easier to solve with pit soils than with the tower silos which are universal in the same regions as the two-storey hay barns, and a general change of method would not be surprising.

GRAIN HARVESTING AND DRYING.

A very full account of the practical operation of combine harvesters and of the complementary processes of drying and storage on the farm has been given by Cashmore (Ref. 25). For anyone who is thinking of buying a combine, this paper gives useful information about the various types available and the design features which affect individual performance. It also discusses the special requirements of the various crops that may be combined, and the possibilities of choosing varieties which will be more suitable than others for harvesting in this way. The paper is likely also to interest the established combine user since it includes a multitude of tips—drawn from a long and varied experience—about

adjustments and odd points which make for efficient working in the field. In another respect, too, this account of combining is better-balanced than some others which have been given over the last few years : it recognizes frankly that the machine in the field is only the first link in a chain of equipment, and deals with the whole sequence from standing crop to safe storage. The latter problem—storage—has assumed an ever-growing importance over the last few years, and has many sides to it. First there is the handling side and, in particular, the difficulties that may arise when existing storage facilities are to be used in association with a new system of harvesting. The layout must be economical as regards both labour requirements and capital cost. In this connexion pneumatic elevation and conveying has advantages since a simple pipe-line, is easier to adapt to individual circumstances, and to vary when necessary, than any ordinary mechanical system of elevators and conveyors. It also fits in with another general line of development which is being actively studied at present. This is the use of specially adapted storage facilities as a partial substitute—or in Southern districts possibly as a complete substitute—for farm grain driers. It is well-known that grain can be held in storage at a higher moisture content than would ordinarily be safe it it can be turned over periodically. Moreover some additional drying will be effected during the turning-over process. A further step in the same direction is to use storage bins which can be ventilated either naturally or artificially. A great mass of experimental results on these questions in relation to wheat is given in a recent U.S.D.A. circular (Ref. 26). But these results as they stand are more suitable for study by research workers and equipment designers than by farmers ; and there are many circumstances like climatic differences to be taken into account before they can be applied over here. Of more immediate interest is an account of a simple experiment with ventilated bins carried out in the North of England last year (Ref. 27). It was found that grain as it came from the combine at up to 26 per cent. moisture content could be safely held for several days if it were ventilated (with the aid of a small motor and fan) for an hour or two each day. In a longer experiment barley originally at 26 per cent. moisture content was held for about 8 weeks, having been ventilated over this period for a total time of 92 hours. The moisture content had fallen to 21.6 per cent. when the experiment was discontinued, and the barley was then still in first class condition.

Two new machines of some importance have made their appearance during the year and reference to illustrated descriptions may be of interest. The first is a British-made self-propelled combine with the larger relative threshing capacity which some of our crops seem to require (Ref. 28) It may surprise some people to recall that this is not in fact the first British-made combine . a few large machines were made for export 15 years or so ago, and one of the same model is still doing a sound job of work during its fourteenth season on an Oxfordshire farm. The other machine is a real innovation—an attempt, in the small farmer's interest, at the cheapest and simplest outfit possible (Ref. 29). It goes a step further than the header (which removes only the ears for threshing) : in principle, this machine does not even remove the ears—it threshes them where they grow.

Two questions which arise from combining, and which are very frequently under discussion, are dealt with in two research notes. One deals with the question of combine losses, giving both simple and more accurate methods of estimation and some results obtained in the field (Ref. 30). The total losses as measured prior to 1944 varied from a minimum of 1.7 per cent. with wheat to a maximum of 10 per cent. with oats. With both wheat and barley the greater part of the loss occurred at the cutter bar. In the very unfavourable 1944 season some still higher figures were obtained from measurements made on ordinary machines as they were found working in the field, and preliminary experiments indicated some ways in which they might be improved. These experiments are now being followed up by a closer study.

The other note refers to the difficulties often experienced over ploughing-in combined straw, and describes a novel form of disc coulter which has given promising results under trial (Ref. 31). Finally, there may be mentioned a simple grain flowmeter which will shortly be available and which may help farmers to regulate their drying more accurately (Ref. 32).

ELECTRIFICATION AND BARNYARD MECHANIZATION.

It is frequently pointed out that most of the more familiar aspects of mechanization—tractors, combines, potato harvesters and so on—have very little bearing on what happens in and around the barnyard, and that it is this side of everyday British farming that most urgently needs labour-saving appliances. The subject is closely bound up with rural electrification, not because electricity is in any way essential for the operation of any particular appliance but because of its convenience and adaptability. And if they are really to save labour barnyard appliances have nearly always to be adapted to particular circumstances. These points are illustrated in one instance after another in a paper by Cameron Brown which was mentioned but not discussed last year (Ref. 33). This deals with the whole field of electricity as an aid to further mechanization, with emphasis on the general trend of development rather than on facts and figures. At the same time the paper gives many definite instances such as an automatically-controlled grinding installation, a particular layout of general food-preparing machinery, an arrangement of silage cutter and blower, and so on, in which thoughtful planning has solved some particular farmer's problem. All these are worth studying: if they are not directly applicable to one's own case, they are at least likely to suggest the right lines to follow.

In another paper (Ref. 34) the same writer has discussed internal farm mechanization without particular reference to electricity. He points out that with a great many everyday machines like cake-breakers, chaff-cutters, root-slicers, and so on there is on most farms little use of imagination and less use of power. There still persists too widely the practice of "put it on the floor and pick it up again." Again, in the dairy, appliances which are sound and labour saving enough in themselves, are very often operated at a disadvantage and so contribute less than they might do to general economy of running, through lack of consideration of the best way of placing them in relation to one another. This paper, too, covers a wide field touching on water supply, grain storage and grass (or rather hay) drying in addition to the topics already discussed.

An even wider field is covered by an American paper on rural industry (Ref. 35). This is concerned more particularly with the area served by the Tennessee Valley Authority and with some of the technological developments which have already contributed, or in the future and with the assistance of agricultural engineers could contribute, to a general raising of farm incomes. In Tennessee alone a million dollars a year might be saved by properly controlled storage houses for sweet potatoes; six million dollars by the proper use of equipment (already developed) for growing and harvesting seed crops; eight million dollars by irrigation of food and vegetable crops; and so on. Once more practically all of the instances seem to lead back to cheap and plentiful electrical power as the main factor in further progress.

There is, however, one other subject—dung handling—which is of great importance at the barnyard end of farm mechanization, but on which electrification has no particular bearing. A general review of the rather limited progress made to date has been given in a paper already quoted (Ref. 13). It is pointed out that this problem, perhaps better than any other, illustrates the real difficulty of the agricultural engineer, which is not so much to make implements which will work as to make implements which will fit sufficiently well into the varied circumstances of farming to become commercial propositions. Four distinct

types of dung loader have been developed over the last year or two by a process of testing, modification, and re-testing until each is reasonably efficient from a technical standpoint. It still remains to be seen, however, whether any one of them is destined to be generally used in farming. The two most likely ones are a direct-loading appliance which works rather in the same way as a rotary cultivator; and a rather simpler outfit in which a power-operated, but hand-controlled, grab is used with a power-driven elevator. Between them, these machines illustrate the two main difficulties which arise when dung-loading inventions are tried out in real farming. The direct loading device certainly enables one man to load dung at an amazing rate, but, as might be expected, is expensive to buy. It loads dung so quickly that there are very few farms on which the general transport organization will stand up to the strain and keep the loader busy. No one will like to see an expensive machine standing idle waiting for carts; yet no one will be willing to buy additional carts just to keep a one-purpose machine at work.

The other machine does not suffer from this disadvantage and is handy enough to work in the confined spaces from which dung has, all too often, to be moved. But it does not greatly increase the output of the men it employs. It makes their job easier and less unpleasant but (if they put their backs into it) they could load nearly as much dung with ordinary forks. However, since the above paper was written, a remote-control device—which eliminates one more man—has been developed for this second loader and this, if successful in practice, will change the picture entirely. This remote control is electrically operated so that, although in this instance only something like a car battery is needed, even dung handling may come back to electricity after all.

SUGAR BEET HARVESTING.

The paper just quoted above also reviews progress under this heading up to last season. So far as machines commercially available here or overseas are concerned, the most notable advance is shown by an American machine which was tried here last year. It is a self-contained outfit built round a tractor which tops and lifts the beet and windrows both tops and roots separately. With it is associated a mechanical loader with which the roots can be quickly picked up from the windrows (each containing the produce of 8 individual rows) in which the machine leaves them. This pair of machines represents a notable achievement because the outfit does the whole job from growing crop to roadside heap at the same labour level. Earlier machines have enabled one or two men to replace a dozen or so in one part of the job: but have left the farmer still wanting more labour than he can easily provide, to finish up what the machine leaves undone. Naturally enough, the new harvester is not perfect. For one thing its topping is less good than that of another and better-known outfit, and in loose ground may not be good enough. Again, its limitations would probably be realised quite quickly on wet or very cloddy land.

Another paper describes how the components of the above and other machines have been studied in the course of developmental research (Ref. 36). Detailed studies of topping and of topping mechanisms have indicated both the present superiority of one particular topping mechanism and the directions in which further improvement and simplification might be sought. Similarly, detailed studies of the cleaning actions of various beet harvesters have given most striking results. Under distinctly unfavourable conditions, in which two of the best available machines put something like 2½ cwt. of soil into the windrow or trailer for every cwt. of beet, another cleaning mechanism, based on an older and almost forgotten machine, only put out some 25 lb. of soil. On the basis of results of detailed studies like this, a complete harvester is being built for trial.

S. J. WRIGHT.

References

1. Brodall, A. P. and Cooper, M. R. "Number and Duty of Principal Farm Machines." F.M. 46 November 1944. *U.S.D. A. Bureau of Agricultural Economics.*

2. Rebman, E. F. "Improving Farm Labour Efficiency." F M 361 Feb 1945. *Michigan State College.*

3. "Country Planning." *Oxford University Press.*

4. Reynolds, F. J. "Relation of Mechanization to Farm Structures." *Agricultural Engineering*, Jan. 1945.

5. "Postwar Objectives for Agricultural Engineers" *Agricultural Engineering*, February 1945.

6. Driftmier R. H. "Post-War Opportunities in Agricultural Engineering." *Agricultural Engineering*, July 1945.

7. Davies, C. "Harvesting Machinery." *Inst. Brit Agric Eng.*, Oct. 1944.

8. Culpin, C. "Machinery for Crop Cultivation." *Inst. Brit. Agric. Eng*, Nov. 1944.

9. "The Nebraska Tractor Tests, 1920 41" *Bulletin No 338 Agricultural Experiment Station University of Nebraska.*

10. Research on Pneumatic Tyres for Farm Tractors." *National Institute of Agricultural Engineering.*

11. Hine, H. J. "Tractor Tyres to Suit all Soils." *Farmer & Stockbreeder*, August 28, 1945.

12. 'The Tractor Industry." *Farm Implement & Machinery Review*, Aug. 1945.

13. Wright, S. J. 'The Work of the National Institute of Agricultural Engineering." Trans. Highland & Agric. Soc. 1945.

14. "A Self-Propelled Tool-Frame." *Farm Implement & Machinery Review*, May 1945.

15. "A new Horticultural Tractor.' *Farm Implement & Machinery Review*, April 1945.

16. Wedderspoon, T. A., and Russell, E. W. "Soil Cultivation." *Inst. Brit. Agric Engineers.* Jan. 1945.

17. Cameron Brown, C. A. "The Application of Electricity to Field Operations." *B. E. I. R. A. Technical Report No. W/T8* 1944.

18. 'Segmented Sugar Beet Seed" *Agricultural Engineering Record, Autumn* 1945. *H.M.S.O*

19. Emerson, A. W. "The Hay Baler's Place in Soil Conservation." *Implement and Tractor*, May 5th, 1945.

20. Dexter, S. T. and Sheldon, W. H. "Mow Drying of Hay." *Michigan Agric. Expt. Stn. Quarterly Bulletin*, Vol. 27, No 3, Feb. 1945.

21. Jennings, B. A. "Mow Curing of Hay." *Agricultural Engineering*, March 1945.

22. Strait, J. "Barn Curing of Hay with Heated Air" *Agricultural Engineering* Nov. 1944.

23. Schroeder, E. W. & Ackerman, W. F. "Making Hay with an Automatic-Tying Pick-Up Baler." *Agricultural Engineering*, Jan 1945.

24. 'Handling Baled Hay and Straw, Field to Storage." *Agricultural Engineering*, May 1945.

25. Cashmore, W. H. "Combines, Grain Drying and Storage." *Jour. Roy Agric. Soc.*, Vol 105, 1944.

26. "Wheat Storage in Experimental Farm-Type Bins" *U.S.D. A. Circular No.* 637.

27. "Grain Bin Ventilation." *Agricultural Engineering Record, Autumn* 1945. *H.M.S.O*

28. 'The 1945 Model Grain Marshall." *Farm Implement & Machinery Review, Sept.* 1945.

29. "A Revolutionary Harvester." *Farm Implement & Machinery Review*, Sept. 1945.

30. "Grain Losses with the Combine Harvester." *Agricultural Engineering Record, Autumn*, 1945. *H.M.S.O*

31. 'A Coulter for Ploughing-In Straw." *Agricultural Engineering Record*, Autumn 1945. *H.M.S.O.*

32. "A Grain Flowmeter." *Agricultural Engineering Record*, Autumn 1945. *H.M.S.O.*

33. Cameron Brown, C. A., "The Electrical Aspect of Farm Mechanization." *Inst. Elec Eng.* 1944.

34. Cameron Brown, C. A. "Internal Farm Mechanization." *Inst. Brit. Ag. Eng.* Feb. 1945.

35. Hurd, C. J. "Rural Industry—A Challenge for Agricultural Engineers." *Agricultural Engineering*, Feb. 1945.

36. "Experiments on Sugar Beet Harvesting." *Agricultural Engineering Record*, Autumn 1945. *H.M.S.O.*

SOILS AND FERTILIZERS

The pattern of post-war farming has still to be determined, and, at the moment, all that is clear is that readjustments are likely to be made far more slowly than in many branches of industry. The whole world is short of food and raw materials, and for farmers the immediate targets remain as high and the difficulties almost as great as in the worst periods of the war. Swords will eventually be beaten into ploughshares, though at first the process may consist of little more than temporary improvisations verging almost on salvage. Ammonium nitrate can go into fertilizers instead of shells, jeeps may serve as light tractors; bulldozers be used for making contour-terraces, poison sprays, bombs and smokes for killing mosquitoes and other insects; flame throwers for burning up weeds. It will be a long time before reorganised industry and transport can supply all the raw materials, implements and buildings farmers need.

In Great Britain the outstanding mechanised developments and reclamations took place during the war years, and the immediate problem is not to extend still further but to consolidate what has been gained. The prospects will often turn on economic and social factors, and, above all, on housing.

Among the indirect gains from the food production campaign one of the most important has been our greatly improved knowledge of the behaviour and potentialities of our soils. Everywhere enthusiastic farmers and county staffs undertook drastic reclamation measures with little first-hand or local experience to guide them. It will be agreed that on the whole they achieved a spectacular success. Good crops have been grown where there had been none within living memory. Dairy farmers and graziers have learnt the arts of arable farming, and some of them are well on the way to securing even better grass in consequence. Before the actual details are forgotten and those responsible are dispersed, it seems of the greatest importance to arrange for a detailed record of all this local experience. This *Journal* made a useful beginning by publishing a number of accounts of reclamations, but something much more extensive and systematic is needed.

1. Soil Classification and Soil Surveys.

The task of interpreting the wartime record would have been simplified and its permanent value increased if we had possessed a well-developed soil survey. Unfortunately soil survey work in Great Britain has been undertaken only on a modest scale, though excellent work has been done in a few special areas, as, for example, in R. Glentworth's studies on the soils developed on basic igneous rocks in central Aberdeenshire (Ref. 1). It has generally been assumed that the nature and properties of individual soils were sufficiently well known by local tradition and experience for valuations to be settled by bargaining between farmer and landlord or buyer and seller, and for questions of land

management to require little more than an occasional advisory visit on details of liming or manuring; the war has shown how dramatically our soils will respond to novel treatments. Long-term planning should be based on the intrinsic properties of the soil and not merely on the results of current methods of land utilization. If we aim at a prosperous and developing agriculture we shall find, as the United States and the Soviet Union did before us, that a fundamental requirement is a sound knowledge of our soil resources. It must inevitably take many years before our national soil survey can cover the whole country even in broad outline, and it is therefore most desirable to have special local experiences carefully recorded so that, later on, they may be properly interpreted in terms of the soil survey and their lessons applied to other parts of the country.

Agricultural bodies must now follow civil servants, industrialists and trade unionists in thinking "globally" on all production questions. The new Food and Agriculture Organisation of the United Nations began its Quebec Conference in October 1945 in the knowledge that two-thirds of the people of the world are under-nourished, ana that new ways must be found to improve the production, distribution and consumption of food. Whatever approaches are made to the economic and social aspects of these problems, it is clear that the limit in each region is set by the nature of its soils. It may therefore be of interest to refer to some attempts to classify and map the soils of the continents and of the whole world.

Fairly recent soil maps of European Russia, Europe and the United States are well known to soil workers. J. A. Prescott, Director of the Waite Institute of Agricultural Research, Adelaide, has put his unique knowledge of the soils of Australia into the form of a map (Ref. 2), and his staff have issued a number of detailed surveys of individual areas. The soils of the tropics present special difficulties, partly because very few workers have been enabled to study soils in more than a single country, and partly because most of the work attempted has been directed to immediately practical objectives. An outstanding exception was the late Geoffrey Milne's brilliant study of East African soils. Another excellent, though somewhat old, piece of work has now been made available in English in E. C. J. Mohr's book "The soils of equatorial regions, with special reference to the Netherlands East Indies," recently translated by R. L. Pendleton, an American worker with a wide experience of soils in the East and now Principal Soil Technologist in the Office of Foreign Agricultural Relations in the U.S. Department of Agriculture.

Although the British Empire includes so large a variety of conditions of soil and agriculture, it is a disturbing reflection that so little has been done in the broad approach to world agriculture and soil geography. It was left to the Chief of U.S. Soil Survey, C. F. Marbut, to attempt the first outline map of the soils of Africa twenty years ago and to a Russian woman soil geographer, Z. Y. Shokalskaia, to make the next revision (Ref. 3). Some may be inclined to underrate the value of soil maps prepared by people who have not even set foot in the continent they have mapped, but bold attempts at synthesis and generalisation by competent and experienced workers are a vital stage in scientific development, even though they may appear at first to do little more than invite criticism and new evidence.

Those of us who were fortunate enough to be invited to the celebrations of the 220th anniversary of the Academy of Sciences of the U.S.S.R. in Moscow and Leningrad in June 1945 saw new and unpublished soil maps of Australia and South America, and special maps, tables and diagrams prepared by Academician L. I. Prasolov, Director of the Dokuchaiev Institute for Soil Research, to illustrate his recent analysis of the distribution of soils over the earth (Ref. 4). The actual soil map was included in the Great Soviet Atlas, published just before the war. The following somewhat condensed summary gives the relative areas of the principal soil types, expressed as percentages of the total land surface of the world

(total 57.4 million sq. miles) and pre-war U.S.S.R. (total 8.4 million sq. miles). Most of the names of soil types are self-descriptive but a few words of explanation and comment may be added. "Podzol" is a Russian folk-name now universally used to describe the highly leached soils of coniferous forests and heaths in the cooler or wetter parts of temperate regions. In the undisturbed state it generally has a raw humus layer over bleached sand and then a zone enriched in iron or organic matter, sometimes to the extent of forming

Areas of individual soil types as percentages of the total land surface of the world and U.S.S.R.

	World	U.S.S.R.
Leached acid soils.		
Tundra	4.0	8.3
Podzols (and bogs)	9.2	31.7
Gray forest soils	0.8	3.4
Brown forest soils*	2.3	—
Soils of dry forests	3.4	—
Red soils of sub-tropical regions	2.5	—
Soils of thin woods and grass savannahs	7.4	—
Red soils of tropical forests	7.2	—
Lateritic soils	2.2	—
Neutral and Alkaline soils.		
Chernozems	2.7	8.4
Prairie soils	1.4	—
Chestnut soils of dry steppes	6.9	5.4
Miscellaneous.		
Various desert soils	17.8	9.7
Various mountain soils	16.3	29.9
Various tropical soils	2.1	—
Alluvial soils	2.9	2.0
Snow, ice, inland water	11.5	1.2

* Includes terra rossa and carbonate soils.

a hard pan. Such soils are common in the north and west of Great Britain and also occur in our southern heaths. Most of the other British soils fall into the "brown forest soils," a rather indefinite transitional class found where the extremes of a continental climate are modified by proximity to the ocean, and more dependent on the geological parent material than most of the other types. It may be noted that our main soil type forms only a very small fraction of the total land of the world and a negligible one in U.S.S.R. The "chernozem" is the famous black earth of the Ukrainian and similar steppes. These fertile soils provide the main granary of the U.S.S.R. and Eastern Europe, but they are not common elsewhere. The most widespread soils are of low intrinsic fertility—various mountain soils unsuited for intensive agriculture, podzols of coniferous forests and bogs, seasonally dry soils of thin woods and grass savannahs, and red soils of tropical forests. Perhaps one value of the above table and the world soil map is to warn us how little we may expect to know of the proper treatment of land in other countries from practical experience gained in our own pleasant but unique little island.

2. Soil Conservation.

The general principles of soil conservation, in the narrow but important sense of preventing undue erosion by water or wind, have often been discussed during the last twenty years but they are not always properly understood. The more glaring examples of rapid

soil erosion are sometimes used as cautionary tales in expositions of special doctrines of soil fertility and agricultural policy, often with a woeful disregard for the actual facts. Soil conservation requires an adequate cover of suitable vegetation to break the force of rain and surface water, to secure its rapid penetration into the soil mass and to anchor the soil. Often mechanical operations such as gulley-plugging, contour-terracing or silt-pitting are required to check the rot, to increase the absorption of water and to aid in starting a sound vegetation cover. Sometimes the whole system of cropping and grazing must be drastically modified. A good vegetational cover maintains the organic matter content of the soil at a higher level than in repeatedly cultivated and exposed soil, but it does not necessarily follow that other ways of increasing the content of organic matter would suffice to conserve the soil and maintain its fertility. The growing plant does many other things besides adding organic matter to the soil. The roots of trees and especially those of grasses open up the soil, and, what is even more important, build up the granular soil structure which is essential if water is to be absorbed rapidly and penetrate deeply and thus build up a useful reserve to carry crop plants through the long dry spells which normally follow the seasonal storms responsible for severe erosion. All the evidence emphasises the vital role of the protective cover of the vegetation and the need for revising agricultural, forestry and pastoral methods so as to favour the cover and restrict the exposure of bare soil.

Soil erosion arouses little immediate interest in Great Britain, for torrential rains are uncommon and most land protects itself by grass, weeds or scrub Some of the lighter sands and fens in the eastern counties are apt to " blow " in the spring, and some farmers are wondering whether they should put down leys more frequently to anchor the soil. One by-product of the war has been to provide us with object lessons on soil erosion where roads run through tank exercise grounds in heath country. The normal vegetation has been stripped off and gulleys are now forming as water sweeps across the bare soil. Before long we can expect to see "dam-plugging" and "contour-terracing" in operation the sooner, the better.

Although the war has necessarily slowed down preparations for soil conservation work in the colonies, some good surveys and practical work have been undertaken, and there is evidence that the native cultivators are responding to some of the propaganda. The Agricultural Advisor to the Colonial Office has reviewed (Ref. 5) progress up to 1943. There are high hopes of really substantial progress during the next decade, since soil conservation and all that it implies should have heavy claims on the £120,000,000 voted under the Colonial Development and Welfare Act.

A few aspects of the general problem may be reviewed by reference to some recent publications. The forester naturally stresses the importance of protecting the shrubs and trees, especially on watersheds and in the more arid areas. His first inclination is to enforce strict closure to cultivation, grazing, firing and cutting in specified areas. He emphasises the importance of the forest in safeguarding the water supply, and he often discusses the difficult question as to how far the forest affects the actual rainfall, as distinct from the subsequent fate of the water after it has fallen. In a recent lecture on these questions E. P. Stebbing (Ref. 6) has suggested that an African International Commission is needed to review the whole problem and to co-ordinate the broad lines of soil conservation work.

R. M. Gorrie (Ref. 7), a forester with a wide experience of soil conservation work in the Punjab, has shown how, as an interim measure, the mechanised equipment of warfare could be pressed into service in the first stages of soil conservation and of bringing new land into cultivation. Heavy machinery for shifting masses of earth—bulldozers, road graders, earth scoops and heavy ditching ploughs—have been employed on a large scale for military purposes in primitive countries where previously there had been no alternatives to the hand-

hoe and head-load. Thousands of Indian and African men have been trained to handle these mechanical giants, which could now be used to solve the two problems of beginning urgent civil engineering works and of finding productive and congenial occupation for trained men in conservation and reclamation schemes beyond the resources of native agricultural methods in sparsely populated areas. African and Indian problems are totally different from our own, for there is often little to be gained by introducing implements into some of the more densely settled areas, where even the humble bullock plough may lead to over-cultivation and erosion. Gorrie has reviewed the more immediate tasks for heavy mechanical power. In the wettest regions, where the first problem is to keep the catchment areas in as absorptive a condition as possible, contouring lightly wooded hill lands would supplement the effect of the vegetative cover ; in level land the need is naturally for drainage. In the intermediate zones with from 30 to 60 inches of rainfall, contour-terracing or ridging is needed to increase the absorption of water and thus encourage the grass and shrubs. In the arid regions it should be possible to extend cultivation beyond the tails of existing canals and to use surplus water from monsoon floods on land parcelled out in contoured ridges. Artificial catchment areas, as used in Rajputana and the Sudan Gezira, could be employed much more widely. Low crescent-shaped banks will hold up sufficient water to guarantee a crop on at least part of the land, where otherwise crops on the whole area might be too precarious to allow settlement and farming by the old methods.

3. Soil Structure and Grass Roots.

In Great Britain and in many parts of the tropics the out-standing problem in maintaining soil fertility is to discover the best way of combining arable cultivation with resting periods under grass or other cover crops. The problems are necessarily complex, for they involve the whole system of farm management. It is scarcely possible without actual experiment to separate the immediate value of the ley for pasture or hay from its secondary effects on soil fertility, as shown in improved yields of arable crops, or to distinguish the chemical or nutritional effects from the physical or structural ones. Unfortunately the long-term field experiments required are laborious and expensive, and so far, only one (at the Woburn Experimental Farm) has been attempted. It is sometimes expected that the soil chemist or soil physicist can settle such questions as the best length of ley or the effects of farmyard manure merely by analysing the soil, but experienced research workers know the limitations of their present techniques and the necessity for good field experiments to enable them to test and develop their laboratory methods. Soil physicists in many countries, and notably in U.S.S.R., have given especial attention to analysing field soils for structure or aggregates by sieving the soil in water to determine the proportion of water-stable crumbs of various sizes. The results in this country have not been clear-cut, perhaps because the actual differences in the field are smaller, and alternative methods are being tried. One striking success of the wet-sieving technique in Uganda may be considered here. It was used by W. S. Martin (Ref. 8) in the interpretation of important observations and field experiments on the vital African problem of discovering a less wasteful form of agriculture than the traditional shifting-cultivation. In the early attempts to solve this problem in both East and West Africa, it was natural that the emphasis should be on using green manures, farmyard manures and composts " to keep up the soil organic matter " and on good cultivation, because these were the features of British practice recommended in the textbooks on which agricultural officers were trained. In Uganda it happened that " good " plots, with careful cleaning and weeding before sowing, often gave poorer yields of cotton in demonstrations than " bad " plots left with clods and weeds. Over-cultivation smoothed and caked the soil so that less water soaked in and more ran off. Rough preparation for big-seeded crops and less late weeding are now recommended. Crumb analyses showed that

neither farmyard manure, cotton seed, green manure nor lime had any significant effect in improving soil structure. Under tropical conditions termites and rapid microbiological decomposition soon oxidise away added organic manures. The clue was found in noting the excellent crumb structure under tall grasses, such as Elephant grass, *Pennisetum purpureum*. It was shown in field experiments that similar crumb structure and deep penetration of water and crop roots could be obtained by " resting " arable land for two or three years under suitable grasses, often those which naturally colonise abandoned land. It is now recommended that on land with sufficient body to form crumbs, all over-cultivation should be avoided and the holding divided into about six fields to allow a rotation with at least two years under tall grass. The practical application of this scheme still presents acute problems, some of which have been discussed by M. D. Graham (Ref. 9) in a thoughtful article based on his attempts to establish pasture-arable rotations on native farms. There is a serious lack of suitable plants for fences or hedges, and it is very difficult to eradicate the deeply rooted tall grass from poor depleted soils. He therefore favours heavily cropped pastures in place of tall grasses, whilst subscribing wholeheartedly to the general objective of " minimum cultivation, maximum cover," planting all crops on land as rough as possible and securing a complete weed cover by the time the crop is due to come off. In a comment added to this paper W. S. Martin admits the difficulty of fitting his grass scheme into small native farms and suggests that it may become necessary to run a whole hillside as a unit with communal cultivation, grazing and, perhaps, eventually machinery.

The technical requirements for improving and stabilizing agriculture in Africa and India are likely to compel drastic social and economic changes amounting almost to revolutions on the scale of those in U.S.A. and U.S.S.R. Another African example is provided in a recent article (Ref. 10) by Lord Balfour, formerly Resident Minister in West Africa. After discussing Nigerian problems in the production of palm oil and the research and education needed, he concludes that only speedy action carried through with " a wartime emergency mentality " can prevent a crippling blow to Nigeria's future economy.

4. Deep Ploughing.

In many parts of England spectacular local successes in clearing scrub land by very deep ploughing with " Prairie Buster " and similar ploughs, drawn by powerful track-laying tractors, have increased the interest in deep ploughing on old arable land, especially for potatoes and sugar beet. Some enthusiasts contrast the good crops on deeply ploughed farms with the poorer ones on similar soil still ploughed in the old manner. They sometimes forget that pioneers using new methods are often highly skilled men not lacking in capital; they tend to confuse deep ploughing and good farming. On some soils there may be a risk of repeating the mistakes which followed the first wave of deep ploughing by steam cable-ploughs. Deep ploughing is clearly valuable where a pan has been produced by the plough or by tractor wheels, but under ordinary conditions its merits are still uncertain. Fortunately the Agricultural Research Council and the Agricultural Improvement Council have arranged for a series of field experiments on depth of ploughing to be undertaken by Rothamsted and the county staffs on a variety of soils. E. W. Russell, who is in charge of this work, has reviewed (Ref. 11) some earlier preliminary results. In general it appears from all the information so far available that it is more important to ensure a clean seed bed than to achieve any exactly defined state or depth of tilth. Ploughing is good when it completely buries the weeds, and this may often be achieved more easily by deep ploughing. It appears that the most economical way of preparing a seed bed by a tractor may be to use a plough with a suitably designed digger breast and set in fairly deep. There are already indications that good cultivation may be more important under conditions of low fertility than in better

soils. Adequate manuring may help to keep down cultivation costs by favouring the crop in its competition with weeds, thus reducing the amount of both immediate and future cultivation—a large crop is one of the best weedkillers. It is also possible that deep ploughing will be particularly useful where the opportunity is taken to plough down certain fertilizers to enrich a greater depth of soil.

Evidence from field experiments is consistent in showing that hoeing acts mainly by killing weeds and not by mulching the soil. It may cause serious damage to crops by cutting their roots. Competition between crops and weeds is particularly important in the earliest stages, *e.g.*, before singling sugar beet. Subsequently there may be little harm in allowing an untidy amount of weed growth. Deep ploughing by burying the weeds more completely may reduce the amount of early hoeing needed. A long series of Rothamsted experiments and many more American ones point in the same direction as the East African ones discussed in the last section. Once a crop is well established there seems little to support old traditions of "keeping the hoe moving to conserve water," or "hoeing the sugar into the beet."

5. Weed Control.

If the prime object of cultivation is to control weeds and not to conserve moisture or aerate the soil, some cultivations might be replaced by other physical and chemical treatments. It must be admitted that by comparison with its manifest importance the scientific study of weed control has lagged sadly behind research on pests and diseases, which in the aggregate probably cause far less loss of crop. Promising beginnings have recently been made in what must rapidly become a vast field of research. Among some of the bigger crops, like sugar cane and cotton, flame-guns are already being used to burn up weeds, and it may prove possible to extend their use to other row crops (Ref. 12). The most promising lines of development are likely to come from chemical weed killers used in improved spraying or dusting machines. Until fairly recently the choice of weed killers was restricted to a few acids and salts, including a number of common fertilizers—kainit, calcium cyanamide and (for lawns) sulphate of ammonia. The possibility of discriminating between weeds and crop plants—most commonly cereals or grasses—turned on differences in the physical conditions of their leaves, more of the spray being held on the broad, horizontal and rougher leaves of charlock and certain other weeds. The whole subject was developed empirically. Gradually the range of possible compounds has widened, interest being taken first in organic compounds which had long ago been used either as fungicides or insecticides. A variety of preparations based on dinitro-ortho-cresol ("dinoc" for short) have given good results in field experiments and farm scale trials during the last few years (Ref. 13).* Great care and perseverance are needed to discover the best conditions in the choice of preparation and the strength to use for specific weeds and crops, according to their stages of development. Spectacular successes will be accompanied by occasional failures in which the weeds are not properly checked or the crop is unduly damaged. Some weeds and crops are particularly sensitive to one but not to another closely related treatment. At first the whole subject may appear risky and bewildering in its complexity, but the very fact of high specificity holds out bright prospects for the future. With greatly extended research it should become possible to define conditions under which specified weeds may be controlled among a variety of crops, including some of the market garden ones. The possibilities seem endless, for so far only a very small number of the thousands of possible organic compounds have been tested or, at any rate, reported in publications. One interesting class of compounds has already reached the commercial scale, through work conducted until recently in secret on security grounds. It occurred to two or three groups of workers at about the same time

*See also Prof. G. E. Blackman's paper in this issue.

that the auxins—the growth-promoting substances of plants—or related synthetic compounds might interfere sufficiently with normal growth to serve as weed killers, and promising preliminary results were obtained (Refs. 14 and 15). One of these products (4-chloro-2-methylphenoxy-acetic acid or "methoxone") has given good results in over a thousand field trials on cereals in Great Britain during 1945. Yellow and white charlock, corn and creeping-buttercups were generally killed outright by dressings supplying as little as 8 ozs. per acre. There was no damage to the wheat or oats and only occasional malformation of barley heads. A few weeds—bladder campion, coltsfoot and cleavers—were unaffected. It is understood that "methoxone" will be available to farmers in the spring of 1946 under the name "Agroxone," a powder standardised for dressings at the rate of 2 cwt. per acre.

6 Lupins as Green Manure.

Lupins have several special properties which make them suitable for improving light acid soils. They are among the few leguminous crops—another is broom—which grow well and fix atmospheric nitrogen on very acid soils. It is known from early work by D. N. Prianischnikow that lupins are particularly successful in obtaining phosphate from mineral phosphate and other difficultly available forms. In sand cultures they have been shown to dissolve more phosphate than they absorb, so that oats can grow fairly well with lupins in sand containing mineral phosphate but scarcely at all in parallel pots without lupins. The lupins in fact behave as a sort of superphosphate factory for the oats. Over sixty years ago Schultz-Lupitz reclaimed sandy heaths in Germany by potash and lupins, and A. W. Oldershaw has had good results with both bitter and sweet lupins at Tunstall in East Suffolk (Ref. 16). In spite of these well-known demonstrations green manuring by lupins has not been taken up at all extensively. Part of the difficulty may be inherent in green manuring in our climate; catch crops are always precarious, and the cultivations for a poor or failed crop may do more harm than good.

Recently D. N. Prianischnikow (Ref. 17) has introduced a new type of lupin into Northern Russia and believes that it holds out great possibilities. He points out that the ordinary blue or yellow annual lupin is open to the objections that it is frost-sensitive, does not set seed north of Moscow and has a large seed which means a high seed-rate and great transport difficulties. He has therefore turned over to *Lupinus polyphyllus*, the ordinary perennial garden lupin. He obtained his original stock of seed from Canada and multiplied it by growing two crops each year, an early summer one in the north and an autumn one in the North Caucasus region. This perennial lupin is more frost-resistant, has smaller seeds and can be undersown like a ley in oats and then either harvested or ploughed in green the following year. In some field experiments its residues gave almost as good yields as a dressing of dung. It is said that this perennial lupin will succeed as far north as Archangel. This crop certainly merits trial in British agriculture, horticulture and forestry.

7. Fertilizer Supplies.

It is difficult to forecast the prospects for fertilizer supplies as the official ban on statistics of imports, production and consumption has not yet been lifted. ***The Economist*** wrote on October 20th, 1945 about a "Famine in Fertilizers," and it is not difficult to see in the present state of Europe, and in transport and currency problems elsewhere, obvious reasons why supplies will remain short and the wartime restrictions and rationing schemes must be retained. Only ammonium compounds and basic slag are produced in this country. Other phosphates, nitrate of soda and potash fertilizers are either imported as such or are made from imported raw materials. Farmers who are impatient to step up their rates of dressing and to have phosphate once more for their grassland, may take some comfort from

the thought that the present rationing scheme ensures a reasonable supply for all the arable land and dairy pasture of the country, and an extra allowance for all soils known to be particularly deficient in phosphate or potash.

The writer of this report has reviewed the whole question of the wartime use of fertilizers and the lessons learnt from it in a pamphlet of the Bath & West Society (Ref. 18). This includes details of the rationing schemes, the fertilizer requirements of the principal crops, the average use of fertilizers and farmyard manure in various regions as shown by random sampling surveys, and the composition and comparative prices of current fertilizers.

In the absence of figures for the British consumption of fertilizers during the war it may be of interest to record the American ones (Ref. 19) as an indication of a great achievement and as a pointer in the direction we may probably follow.

Fertilizer consumption in the United States.
Thousand short tons.

	All fertilizers	N	P_2O_5	K_2O
1939	7,993	398	789	409
1940	8,656	419	912	435
1941	9,381	458	994	467
1942	10,131	399	1131	547
1943	11,754	506	1243	643
1944	12,468	626	1305	642

In the decade ending in 1944 the total nitrogen increased by 28%, the phosphoric acid by 46% and the potash by 44%. The large rise in phosphate fertilizers was due in part to the supply of concentrated materials, some of novel types, and in government aid to demonstration farms undertaking improved soil conservation measures. The general movement towards more concentrated kinds of fertilizers is shown by considering the total plant food content expressed as $N + P_2O_5 + K_2O$. This rose from 14.5% in 1900 to 18.1% in 1930 and 20.6% in 1944. The overall ratio of $N : P_2O_5 : K_2O$ still remains close to 1 : 2 : 1, as in this country and the world as a whole. Fertilizers are now spreading into the Middle West States. Although the total is still very small the rate of increase is rapid; Iowa increased its consumption eightfold during the war. The figures for total annual consumption during the war show a temporary shortage of nitrogen fertilizers in 1942, which was met by restricting their use on certain crops, and then a rapid increase as new plants came into production. The United States can now satisfy their own potash requirements, and they were, of course, able to export phosphate fertilizers to this country during the war. By contrast Great Britain had ample nitrogen fertilizers but had to ration phosphate and potash fertilizers, the latter particularly rigidly.

8. Nitrogen Fertilizers.

Synthetic ammonia now provides the bulk of our nitrogen fertilizers. Production of synthetic ammonium nitrate for munitions was greatly increased during the war in all industrial countries. The future pattern of our fertilizer industry may be considerably modified if the new plants can continue to produce ammonium nitrate for agriculture. Those factories have the advantage that they require no raw materials beyond coke, air and water; and the product is an excellent fertilizer with 35% nitrogen. It possesses, however, the serious disadvantage of being hygroscopic and, unless protected, picks up water from the air until it becomes damp and cakes. One remedy is to granulate it with calcium carbonate to produce materials like the proprietary article "Nitrochalk," but this process is apparently feasible only at a few of the largest factories. In Canada and the United States detailed investigations have been made on alternative methods of protecting ammonium nitrate (Ref. 20). Starting with a product with less than 2% moisture, sprayed

or grained to the 8 to 16 mesh size, adding 3 to 4% of kieselguhr, clay or other suitable conditioner and 0.5 to 1.0% of a water repellent (paraffin, petrolatum, asphaltum or rosin), they have produced material which, in sufficiently moisture-proof bags, can be stored in a drillable condition for at least a year, even in humid regions. Trial consignments have behaved well under storage and in the fertilizer drill in Britain, and small proportions have been included in our mixed fertilizers during the last year or two.

As ammonium nitrate is used as a high explosive in combination with TNT, anxiety has been expressed about the risk of explosion and fire hazards of ammonium nitrate in the fertilizer factory or farm. Reference has often been made to the dreadful explosion at Oppau, Germany in 1921, but this happened when a 5,000 ton mass of a mixture of ammonium nitrate and ammonium sulphate was being blasted out. A critical examination of recorded explosions and fires and a detailed laboratory study (Ref. 21) have shown that ammonium nitrate is not considered explosive under transportation conditions or when stored in wooden receptacles or paper bags by itself and apart from other explosive substances. Ammonium nitrate in bulk, as it supports combustion, offers much the same fire hazard as sodium nitrate. It should of course be stored well away from other inflammable material, and used bags should be burned promptly.

9. Phosphate Fertilizers.

There are signs of great developments in the production and use of phosphate fertilizers. Improvements are certainly needed, for there is a rapidly growing demand for phosphate in both new and old systems of farming and the average degree of utilization by crops is regrettably low. Whereas one-half or more of the nitrogen or potash in fertilizers is commonly taken up by the crop, it only rarely happens that a quarter of the phosphate is recovered. Commonly between 80 and 90 per cent. of the phosphate added is locked away in the soil in useless forms. Greater efficiency can be achieved by fitting the amounts and forms of phosphate fertilizers more closely to the requirements of individual crops and the properties of different kinds of soil. This requires a large amount of systematic field experimentation and laboratory research, such as is already in progress in most countries with modern systems of farming, though it has scarcely been commenced in the tropics. Another way is to introduce the phosphate fertilizer into the soil close to the seeds so as to supply a high concentration of readily available phosphate at the time and in the place where the young plant most needs it. Drilling phosphates down the same spouts as cereal grain has long been standard practice in Australia, New Zealand and parts of America, where it was originally introduced as a labour-saving device. Combined fertilizer seed drills developed in those countries were imported into Britain during the war and have proved efficient and popular. An illustration of their value is given by field trials carried out by the Soil Research Institutes and County Technical Development Sub-Committees in 1944 (Ref. 22). For cereals 1.5 cwt. of superphosphate per acre drilled with the seed was just as effective as 3.0 cwt. broadcast. In the United States co-ordinated investigations have been in progress over nearly twenty years by a body representing the research institutes and the manufacturers of fertilizers and implements. The principal problem is to find suitable ways of applying fertilizers to cotton, maize, potatoes and other crops grown in rows at the standard distance of one yard apart. It is clearly inefficient to disperse fertilizer through the whole mass of soil between wide rows, and yet dangerous to have a high concentration of salts close to the seeds. The general recommendation at present is to place the fertilizer about 2 inches below and 2 inches to the side of the seeds. A beginning has been made in similar investigations in this country.

Other ways of approaching the phosphate problem are by long-term fundamental investigations on the geology of phosphate deposits and the chemistry of phosphates,

including the chemical engineering problems involved in making new phosphate fertilizers or in finding alternative ways of preparing old ones. Exciting prospects of big developments are already foreshadowed by this kind of work, which hitherto has been undertaken by large government teams of research workers in the United States and the Soviet Union. Great Britain, the original home of the fertilizer industry, appears to have been content to stick to those old and well-tried materials superphosphate and ammonium phosphate. It has no official research organization for fertilizer manufacture and development. Although the British Empire is singularly lacking in known phosphate deposits, there does not appear to have been any adequate geological research on their formation and distribution.

In the Soviet Union the Scientific Institute for Fertilizers and Insectofungicides approached the phosphate problem by organising " complex research " with large teams of specialists simultaneously attacking all the related branches of the subject. (This pattern of research organization has, of course, been rapidly developed elsewhere during the war, the supreme example being the investigations on the utilization of atomic energy). A group of chemical engineers solved the problem of utilizing the crystalline apatite of igneous origin in the Kola peninsula by using a flotation process to produce a concentrate fit for metallurgical and other high-temperature processes. A group of geologists, mineralogists and chemists undertook fundamental research on the conditions under which sedimentary mineral phosphates or phosphorites are formed. Deposits of phosphatic concretions occur in innumerable localities in marine sediments of all geological ages, but most of them are too small to be of economic importance and others are of too low grade to give good superphosphate. Massive bedded phosphates of high grade, as in North Africa, are very rare. Until recently the only phosphate deposits known in the Soviet Union were of the concretionary type, and it was not until the late 1930's that the first really massive bedded phosphate was found in the Kara Tau range. It was recognised, the outcrops traced and valuable new deposits found as the result of a theory developed from the fundamental research. By studying the physical chemistry of phosphate precipitation from dilute solutions in relation to oceanographic data and the detailed paleogeography of known deposits, A. V. Kazakov (Ref. 23) concluded that phosphate deposits are formed where cold bottom waters well up against a continental shelf at a fair distance from the shore. The limits of depth are fairly well defined and geologists in the field can now tell in advance where they should look for the thick deposits of high-grade bedded phosphate. Their practical achievements will ensure a great advance in Russian agriculture as soon as the necessary factories and railways can be built (Ref. 24). It is tempting to speculate on the possibilities which might ultimately emerge from similar research in Africa (south of the Sahara), India and Australia, all countries with acute needs for phosphate but lacking known suitable deposits.

A new phosphate deposit was developed during the war in Uganda (Ref. 25). This may have the indirect value of stimulating work on the nutritional requirements of African crops, as hitherto it has been the custom to treat fertilizer problems on native holdings as remotely academic in view of the prohibitively high costs of imported materials.

The United States has ample known reserves of phosphate rock and rapidly expanding demands at great distances from the mines. This encourages work on new processes yielding more concentrated products than ordinary superphosphate. For many years teams of chemists have investigated the chemical nature and properties of phosphates and new methods of converting mineral phosphates into more readily available materials. Since 1940 they succeeded (Ref. 26) in producing more than 300,000 tons a year of what is termed in this country " triple superphosphate," though on historical and chemical grounds the original term " double superphosphate " is to be preferred. Phosphoric acid is first made by treating phosphate rock either with sulphuric acid or in an electric or blast furnace, and

then used to dissolve a second lot of mineral phosphate giving a product with 40 to 48 per cent. available phosphoric acid as compared with about 20 per cent. when ordinary superphosphate is made by treating rock phosphate directly with sulphuric acid. In 1943 over half this triple superphosphate was exported, and British farmers in consequence learnt to appreciate its merits. On some highly mechanized farms it will seem clumsy to have to go back to ordinary superphosphate, as the American supplies stop.

A still more concentrated product, calcium metaphosphate, with the equivalent of over 60 per cent. available phosphoric acid, was produced (Ref. 27) shortly before the war, but more recently great interest has been taken in other furnace methods. The essential problem was to break down the fluorapatite in the mineral phosphate, remove the fluorine and leave a true tricalcium phosphate, which has been shown by laboratory work to be highly available to plants even though it is insoluble in water. The technical problems involved have been studied for ten years in pilot plants of the U.S. Department of Agriculture and the Tennessee Valley Authority (Ref. 28) and it now appears that a " fused tricalcium phosphate " has reached the stage of commercial production. If this or other forms of defluorinated phosphate could be prepared economically on the sites of the main phosphate deposits, the whole fertilizer industry might undergo profound changes for a stable, concentrated and highly available fertilizer, fit for immediate use, could be shipped instead of raw material needing processing. The high availability to plants of tricalcium phosphates insoluble in water shows that the old convention of valuing phosphate fertilizers by their water-solubility may soon have to be revised. The new products will also serve in another branch of farming—as substitutes for steamed bone flour in mineral supplements for animals. Ordinary mineral phosphates and superphosphate cannot be used for this purpose because their high fluorine content would be injurious to animals. Defluorinated phosphates are both safe and efficient (Ref. 29).

It has been indicated in a Ministry of Supply Order (Ref. 30) that a new phosphate fertilizer " Silico phosphate " may shortly be prepared in this country by sintering ground phosphate rock with an alkaline material in the presence of silica.

The question has often been raised whether the calcium present in superphosphate has any nutrient value for crops. Early comparisons between ordinary fertilizer mixtures and the concentrated compound fertilizers based on ammonium phosphate showed that the older forms were to be preferred for small-seeded crops on acid soils in wet districts, and an extreme example has appeared in wartime reclamation work. On very acid peaty soils in the hills of Montgomery potatoes gave better results with ordinary compound fertilizer than with a concentrated one based on ammonium phosphate, presumably because in soils so acutely deficient in lime the small amount of extra calcium was useful (Ref. 31). But, even under such conditions, it would be dangerous to regard the calcium in superphosphate as an adequate substitute for lime, which must be furnished in such basic forms as the oxide, hydroxide, carbonate or silicate. On moderately acid or neutral soils there is little ground for ascribing much value to the calcium in ordinary superphosphate in comparing it with triple superphosphate or ammonium phosphate.

10. Other Fertilizers and Manures.

(*a*) *Potash fertilizers.*

Although the immediate prospects of obtaining more potash are not very bright, there should be ample supplies as soon as Europe settles down and transport improves. There are vast reserves in Germany, France and Poland and moderate ones in Spain and Palestine. The United States are self-supporting and the Soviet Union is now said to have 80% of the known reserves in the world.

(*b*) *Liming materials.*

The supply position in Great Britain has been greatly improved during the war, but farmers appear to have been slow to appreciate the merits of ground limestone which is now being produced in large quantities. Some of the difficulty may arise through tricks of everyday speech. Because we commonly speak of "liming" land some farmers think that caustic lime should be used and that unburnt limestone is in some way only a substitute. This is quite wrong. Although nearly twice as much ground limestone is needed, its cheapness and its ease of storage, handling and distribution more than make up in convenience and efficiency for the larger bulk, except perhaps where a light dressing has to be put on at the last minute as a precaution in a field which, for some reason, missed its routine dressing.

(*c*) *Organic manures.*

In the last few reports in this series Sir John Russell reviewed in some detail recent work on soil organic matter and farmyard manure. He also discussed the views of those who dislike fertilizers and experimental evidence, and are content to ascribe unique virtues to compost. Here it will suffice to refer to two other authoritative statements, one by W. G. Ogg, Director of Rothamsted Experimental Station, and H. Nicol on "Balanced manuring" (Ref 32) and the other by E. J. Salisbury, Director of the Royal Botanic Gardens, Kew, on "Organic and Mineral fertilizers" (Ref. 33), and to quote a sentence from the latter paper, "The presentation of manurial problems as a controversy concerned with organic manures versus mineral fertilizers is due to confusion of thought and complete failure to apprehend either the facts or the problem."

E. M. CROWTHER.

ROTHAMSTED EXPERIMENTAL STATION,
HARPENDEN, HERTS.

References

1. GLENTWORTH, R. *Trans. Roy. Soc. Edinburgh*, Vol. 61, 1944, pp. 149-170.
2. PRESCOTT, J. A. *Aust. Counc. Sci. Indust. Res.* Bull. 177, 1944, pp. 1-15.
3. SHOKALSKAIA, Z. Y. *Pedology* No. 9, 1944, pp. 419-425.
4. PRASOLOV, L. I. *Pedology* No. 3-4, 1945, pp. 146-151.
5. TEMPANY, H. A., RODDAN, G. M. and LORD, L. *Emp. J. Expt. Agric.*, Vol. 12, 1944, pp. 121-153.
6. STEBBING, E. P. *J. Roy. Soc. Arts*, Vol. 93, 1945, pp. 289-304.
7. GORRIE, R. M. *J. Roy. Soc. Arts*, Vol. 93, 1944, pp. 49-61.
8. MARTIN, W. S. *Emp. J. Expt. Agric.* Vol. 12, 1944, pp. 21-32. *E. Afric. Agric. J.*, Vol. 9, 1944, pp. 189-195.
9. GRAHAM, M. D. *E. Afric. Agric. J.*, Vol. 11, 1945, pp. 3-9.
10. LORD BALFOUR OF INCHYRE. *The Times*, Oct. 31, 1945.
11. RUSSELL, E. W. *Inst. Brit. Agric. Eng.* Jan. 30, 1945.
12. FARWELL, F. E *Sugar*, Vol. 40, No. 2, 1945, pp. 35-36. NEELY, J. W. and BRAIN, S. G. *Miss. Agric. Expt. Sta. Circ.*, 118, 1944, pp. 1-6. HARDY, W. D. *Agric Gaz.* N.S.W. 55, 1944, pp. 470-473, 504. COLE, C. E., DOERY, A. C. and MCALPHIN, D. M. *J. Dept. Agric. Victoria*, Vol. 42, 1944, pp. 494-496, 499.
13. BLACKMAN, G. E. *J. Min. Agric.*, Vol. 51, 1944, pp. 38-41.
14. HAMNER, C. L., TUKEY, H. B. *Science*, Vol. 100, 1944, pp. 154-155.
15. SLADE, R. E., TEMPLEMAN W. G., SEXTON, W. A. *Nature*, Vol. 155, 1945, pp. 497-498. NUTMAN, P. S., THORNTON, H. G., QUASTEL, J. H. *Nature*, Vol. 155, 1945, pp. 498-500. BLACKMAN, G. E. *Nature*, Vol. 155, 1945, pp. 500-501.
16. OLDERSHAW, A. W., GARNER, H. V. *This Journal*, Vol. 105, 1944, pp. 98-114.
17. PRIANISCHNIKOW. D. N. *Trans. Timiriazev, Agric. Acad. Moscow*, Vol. 30, 1945, pp. 5-20.

18. Crowther, E. M. *Bath & West Society Pamphlet*, No. 13, 1945.

19. Mehring, A. L., Wallace, H. M. and Drain, M. *J. Amer. Soc. Agron.*, Vol. 37, 1945, pp. 595-609.

20. Ross, W. H., Adams, J. R., Yee, J. Y., *et al.* *Indust. Engng. Chem.* Vol. 36, 1944, pp. 1088-1095. Ross, W. H., Yee, J. Y. *Amer. Fert.* Vol. 102, 1945, No. 7 and also various papers in *Amer. Fert.* Vol. 99, 1943, Nos. 7 and 8; Vol. 101, 1944, No. 10.

21. Davis, R. O. E. *U.S.D.A.* Circ. 719, 1945, pp. 1-22. *Chem. Met. Engng.*, Vol. 51, 1944, p. 101.

22. Crowther, E. M. *J. Min. Agric.*, Vol. 52, 1945, pp. 170-173. Stewart, A. B. and Reith, J. W. S. *Scottish J. Agric.*, Vol. 25, 1945, pp. 167-171, see also Hanley, F. *J. Min. Agric.*, Vol. 50, 1944, pp. 493-496. Lewis, A. H. and Strickland, A. G. *J. Agric. Sci.*, Vol. 34, 1944, pp. 73-75.

23. Kazakov, A. V. *Trans. Sci. Inst. Fertilizers & Insectofungicides (U.S.S.R.)*, 1937, No. 139, No. 142; 1939, No. 145. No. 142 was published in English for the XVII International Geological Congress and includes other related papers. Further details are given in No. 146.

24. Kartsev, M. *Fertilizer J.*, Vol. 31, 1945, pp. 663-664.

25. Jones, G. H. G. *E. Afric. Agric. J.*, Vol. 10, 1945, pp. 195-97.

26. Mehring, A. L. *U.S.D.A.* Circ. 718, 1944, pp. 1-24.

27. Volkerding, C. C., Bradfield, R. *Proc. Soil Sci. Soc. Amer.* (1943), Vol. 8, 1944, pp. 159-166. Frear, G. L., Deese, E. F., Lefforge, J. W. *Indust. Engng. Chem.*, Vol. 36, 1944, pp. 835-840.

28. MacIntire, W. H., Winterberg, S. H., Hatcher, B. W. *et al.* *Soil Sci.*, Vol. 57, 1944, pp. 425-442.

29. Hill, W. L., Reynolds, D. S. Hendricks, S. B. and Jacob, K. D. *J. Ass. Off. Agric. Chem.*, Vol. 28, 1945, p. 105 and two following papers.

30. Statutory Rules and Orders, 1945, No. 234.

31. Davies, R. O., Fagan, T. W., John, J. L. *Emp. J. Expt. Agric.*, Vol 12, 1944, pp. 54-60.

32. Ogg, W. G., Nicol, H. *Scot. J. Agric.*, Vol. 25, 1945, pp. 76-83.

33. Salisbury, E. J. *J. Roy. Hort. Soc.*, Vol. 69, 1944, pp. 287-290.

THE BLACK FEN

THE TERM Black Fen is a somewhat misleading one and Peaty Fen would be more correct, for the soil varies in colour from light brown to a sooty black. Intermixed with this dark-coloured soil one finds varying shades of grey due to exposed clay and to areas of silt. There are even snow-white patches marking the sites of old meres, whose beds were formed of the shells of fresh-water molluscs. Despite the lack of bright colours and the flat almost treeless landscape, the prospect is not dreary and has a charm of its own, except in the wet dark days of December. Another confusing point in nomenclature, is that when the fenman speaks of fen, he means the peaty land. The outsider on the other hand does not distinguish between the peat and the siltland, though in the latter case the landscape is different to a remarkable degree and so too is the farming and the life of the inhabitants. The peaty fenland is like a country within a country, and the fenman conforms to a definite type, despite the varied sources of his origin.

The area to be described covers about 200,000 acres with the Isle of Ely as its centre. Parts of the adjoining counties of Huntingdon, Cambridge, Suffolk and Norfolk possess a certain amount of peaty fen. Dotted about the peaty fenland are " islands " such as those on which Ely town and Littleport are situated. These were islands in the literal sense before the fens were drained and they are raised ground, consisting of clay and gravel. There is a sharp line of demarcation between the soil types, and the character of the farming differs just as markedly. The larger farmers and many of the farm workers and small holders live on the upland or the " islands " and go to work in the fen during the day. Along the margins of the fen adjoining the higher grounds is a zone of varying width referred to as skirtland. Silt intrudes into the fen at many points and it marks the beds of former rivers and their tributaries.

Holdings are small, though one often finds a number of scattered farms under one man. Taking the Isle of Ely as an example, out of a total of approximately 4,000 holdings, 1,000 are under 5 acres and 2,000 under 15 acres. Slightly more than 500 exceed 100 acres. One of the worst features of fenland farming is the lay-out of the holdings, the land farmed by a single individual being often scattered so widely that a great deal of travelling time is necessary. This has probably given rise to the assertion that all the equipment needed to farm the fen is a hoe and a bicycle.

A displeasing feature of the more remote fens is the absence of good farm buildings, and the housing of stock in wooden hovels and badly constructed straw-yards. Some well-designed yards have, indeed, appeared in recent years, but most of the farmsteads are sorry affairs, composed of tarred wood and corrugated iron in varying stages of dilapidation. The housing of the inhabitants is little better. There are few substantial farmhouses and most of these have settled in a manner reminiscent of the salt mining districts of Cheshire. It is because of this settling that many people have put up wooden bungalows, adapted railway carriages and, in some parts, wooden shacks which look unfit for human habitation. One gets the impression, not so much of a new country, but of a country in which the settlers do not intend to stay very long so that everything is of a temporary nature. The shrinking of the peat and in many parts the everpresent flood danger provide the reason.

The position regarding roads has improved to some extent, due to the laying of concrete roadways during the war, but the wide droves are still a feature of the landscape. These involve a great waste of land and moreover they are almost impassable in winter. As soon as a track becomes too much of a quagmire, the traffic shifts on to drier ground, until by

spring the whole roadway is a bog. When the soil dries, it is levelled and rolled and in summer one has a sound but weedy road. The isolation of some of the farms in winter is worse than in the Scottish Highlands, and the education of young people has suffered in consequence. Development of quite large tracts has been impossible and crops which must be hauled off in winter cannot be grown.

The climate of the Fenland is excellent, now that drainage has removed the causes of fen ague and the damp living conditions. The rainfall is about 22 in. per annum and the number of hours of sunshine is comparatively high. Not only may the district be described as sunny, but there is a peculiarly intense light, due to the clearness of the atmosphere. This has an effect on soil temperatures and, as will be seen later, contributes to the blowing of the soil.

Systems of Farming.

There is little animal husbandry, and dairy cows are almost a rarity. So few are kept in some fens that the supply of cow's milk does not meet the needs of the people living there, and large numbers of goats may be seen tethered at the wayside and on the banks of the rivers. Bullock feeding in yards is the chief means of utilizing waste products and of making dung. The yards are often badly constructed and exposed to cold driving winds and the water supply presents problems. It is for this latter reason that heavy weights of mangels are fed, which often provide all the water the animal requires. Despite the close proximity to beet factories, the pulp does not seem to have found as much favour as a feeding stuff as one might expect.

In the days before the war many fen farmers went in for pigs in quite a large way, and on many farms these replaced bullocks entirely. A few modern buildings of the Danish type were to be seen but in the main the animals were kept in straw-yards. Swine Erysipelas was endemic and caused a great deal of trouble, so also were joint weaknesses which were commonly ascribed to rheumatism, but were mainly due to protein or mineral deficiencies in the diet.

A few sheep are folded on the light fens and are often kept for the sugar beet tops alone, but in some places leys are grazed before the tops are ready. It is mainly on fens adjoining the uplands that one finds this practice. As may be imagined, the peaty fens are not really suitable for sheep, fluke and foot rot giving a good deal of trouble. The fenman, too, can hardly be expected to have much inherent skill and experience in shepherding.

It is frequently said that a return of livestock would solve many of the fen farmers' problems, but there are many reasons to doubt this belief. Those who point to the past history of the fens as an example, seem to forget there is no record of livestock having been kept, in any numbers, on the peaty fen. It was on the silt land that one would have found the sheep and cattle to which Cobbett referred. Apart from the fact that upland farmers used adjoining fen for summer grazing there was no place for livestock on the wet peat. A visitor to the southern Fenland wrote on 19th June, 1763 : "There are 1,400 cows in the parish of Cottenham which feed on the fens in the summer. The water is, in this dry season, up to their bellies." (1). This shows that fen pasture provided only summer grazing near to the uplands and unsatisfactory grazing at that. In view of the fact that arable farming dominates this area of peaty land, one would expect to find a definite system of rotation, but there is really no system at all ; there can be little doubt that the reason is that, in the days of low prices, only the crops leaving a margin of immediate profit were grown. For some years before the growing of wheat was made remunerative, and before the present war, the only crops which could be grown with any financial success were sugar beet and potatoes. Many farms show a long record of these two crops only, and they were not even always alternated. Over the peaty fen as a whole, potatoes had priority over sugar beet.

Wheat occupied third place, though peaty soils are not really suited to the crop nor is there much chance of its success on newly reclaimed fens. Rye did succeed, but found little favour before the war. Oats meet with moderate success, but the fenman seems to regard the crop with some slight contempt and one hears of intractable fen being "put down to oats," much in the same way as the upland farmer speaks of "putting down to grass." By contrast with milk-producing and cattle-feeding farms, there is obviously little demand for oats for stock-feeding on a fen farm.

Celery growing has long been a feature of farming on peaty fen and many farmers have made a speciality of the crop. The plants are usually raised at a distance and may be grown as far afield as Yorkshire. The light peaty soil makes ridging and other operations comparatively easy and the unrestricted water supply is ideal for this crop. Except that celery is considered to be eminently suited for fen in process of reclamation, it cannot be said to occupy any special place in the rotation.

The fenman is always eager to try new crops, and displays no conservatism in this respect. That the limited selection of crops was due to unremunerative prices, is borne out by the great increase in the number grown during the war. It is quite common to see fields of onions, leeks, chicory, and ryegrass (grown for seed), sights that would have been considered unusual a few years ago.

The growing of onions has been encouraged by war-time scarcity, and the practice has been borrowed, as it were, from Bedfordshire; chicory is, however, a new and interesting departure. Despite many stories as to its purposes, including munitions of war, it seems that it is used entirely as a coffee substitute. One cannot obtain definite figures as to the acreage grown, but this is probably in the neighbourhood of 2,000. The heaps of chicory which line the roads in winter, apparently unharmed by hard weather, give the impression of extensive cultivation.

That the fen farmer will continue to look for new crops cannot be doubted. Quite apart from the matter ot prices, restricted cropping has produced the major problems of potato-root and sugar-beet eelworms, and a failure to practise a wider rotation will, in the absence of some other practicable control, mean that these crops will disappear. Salad crops have been developed to some extent on areas where the peat is becoming thin. It is probable that the growing of flowers and herbaceous perennials will be a venture for the future. The war put a stop to a few promising attempts.

Pastures, whether permanent or in the form of new leys, are few and far between, but there is a considerable tract of permanent grazing running in a narrow strip right through the heart of the Fenland. This occupies 5,000 acres and is about 22 miles long. It forms the Washland between the New and Old Bedford Rivers and acts as a safety reservoir in times of flood. The soil is rich but the herbage is poor and no doubt owes its reputation as pasture to the fact that it is understocked. Grazing is practically uncontrolled and as the land is under water in most winters, and summer floods are not unknown, little attempt is made at improvement.

Quite considerable areas of peaty fen have been reclaimed since the war and have provided interesting cropping problems. They have proved that, despite our newer knowledge, the early fen farmers were right in asserting that they had little choice of crops for some years, until the land became fit for cereals. To their limited choice of coleseed and ryegrass, we can add only celery and potatoes as crops that can be grown with any prospect of success, and they unfortunately make heavy demands on seasonal labour.

Apart from the problem of blowing of soil, which will be considered later, one cannot say that the peaty fen demands any great skill from the cultivator, as compared with that needed to manage stiff clay or dry thin chalk soils. One gets the impression that, on many holdings, the implements are out of date and ill suited to the type of soil. Under-loading

of tractors is quite common—for the soil is not heavy or retentive—but many of these shortcomings are due to the comparatively small size of the holdings. Conditions on the peaty fen are ideal for many of the hand-operated appliances and small tractors, for the land is light, stoneless and as level as a table.

There should be a good field for the development of suitable implements and hand tools and there are problems in this direction which would repay study by the engineer. This is particularly true in the case of rollers and drills. Because of the peculiarly resilient properties of the peat, consolidation of the soil is not achieved by the present types of roller. There is great need also for the development of seed drills, especially of the "combine" type, for a dry dusty surface is characteristic of most fen soils, even where the water table is high.

Fen Drainage.

It is a curious feature of fenland farming that everything is dominated by drainage problems; so it has been since the very beginning of cultivations in this part of the country. There are two main features of the drainage, the first being the conveyance of upland waters to the sea, across the Fenland, and the second the drainage of the Fen itself. The first is an engineer's problem entirely, but the other, which is spoken of as internal drainage, is one for co-operation between the engineer and the agriculturist.

The internal system of drainage practised in the Fenland is extremely complicated, and the intricate network of open drains or ditches, main drains, small rivers, cuts and lodes, to say nothing of the Ouse and the Old and New Bedford rivers, is so bewildering to the stranger that he abandons any hope of understanding it. The location of sluices and pumping stations is even more confusing. Everything seems to have been built up in a hotch-potch fashion, without any preconceived plan. This is true to some extent, but a clear understanding can be obtained by studying the history of Fenland drainage. This is admirably set out in "The Draining of the Fens" by Darby (2), which provides also an historic record of agricultural conditions since the drainage.

Attempts were made in a small way before Vermuyden commenced his enterprise, but his work constituted the first serious attempt. Before 1631, when he cut the Old Bedford river from Earith to Denver and split the peaty fenland into two halves, the Ouse conveyed all the upland water across the fens to the sea by meandering through the south east of the Fenland and collecting tributary waters from Suffolk and Norfolk. Its exact course is somewhat doubtful, but it formed a huge bow away round the east side of the island of Ely. The cutting of the Old Bedford river, and twenty years later the parallel New Bedford river, was intended to short-circuit this bow of the Ouse and take the waters in a straight line from Earith to Denver. The area of peaty fenland south of these two rivers is known as the South Level and that to the north as the Middle Level. Much of the land in the Middle Level is silt. North of a line drawn from Peterborough to Denver Sluice is situated the North Level. This latter contains no peaty fen and need not be considered in this account.

It is always easy to be wise after the event, but it would appear that when this main attempt to drain the fens was made, in the middle of the seventeenth century, two fundamental mistakes were committed. It was not realised that more water entered the river Ouse during its course through the fens, from Earith to Denver, than came from the uplands beyond Earith. The other mistake was that the rapid shrinking of the peat, consequent upon drainage and cultivation, was not anticipated. The result of the latter phenomenon was that the beds of the Ouse, the Old and New Bedford rivers, and many other water-courses were soon above the level of the land. The rivers were banked up by dredgings and transported clay but were, of course, built on a bed of unstable peat.

When the rivers are swollen with flood water from the uplands and with water pumped

into them out of the fen itself, and when the sluice-gates at Denver are shut against the tide, the banks sometimes burst under the strain and several disastrous floods have been experienced. The most notable of these was in 1914, when a vast area of the South Level was under water for the best part of two years. Such major disasters, and the threat of them, gives a feeling of insecurity, which has a profound effect on farming. It is because of this danger that a scheme has been adopted, to be put into effect in the near future, which will remove the danger of flooding from the South Level as it has been removed from the Middle Level by the erection of the great sluice at St. Germans. The details of this scheme cannot be considered in a short account of Fenland farming, though it is interesting to add that it is much the same as that commenced by the Romans and abandoned when they left this country.

Internal drainage, the removal of water by pumping from the land up into the rivers, is a matter for both engineer and farmer, and, with the shrinking of the peat, it presents a problem of the first magnitude and one of increasing difficulty. To the outsider, the whole history of internal drainage appears to have been one of controversy and friction; and the outlook of individuals, at every point from the furthest fens to the outfall at King's Lynn, is peculiarly parochial.

It appears that in past years, as each area was reclaimed, a drainage board was set up for that area. The commissioners of the board were responsible for administration of the area, which was not, in its functioning, a drainage entity; moreover the board's interests probably conflicted with those of the adjoining board. Some of these bodies did their work well, while others did not. A graphic account of the state into which some areas had fallen is to be found in Alan Bloom's book, "The Farm in the Fen." Matters have been remedied to a large extent by the creation (in 1934) of the Gt. Ouse Catchment Board. This Board has directional powers over the internal Boards. There are 70 boards in the Middle Level and 25 in the South Level. They are represented on the Catchment Board and must seek its approval to any proposed reorganization.

This new administration has by no means settled all the problems of internal drainage. It can be said that the engineer can move water as he is requested to do, and that he has control of the situation; but the farming community have, on the other hand, no definite knowledge of their own needs. There are many conflicting interests, for the wheat grower demands a low water table, while the celery grower demands a high one. There are many schools of thought on the general objective of drainage but they can all be classified broadly under two heads, the "wets" and the "drys." One school believes that over-draining is the ruin of fen farming and is responsible for blowing of the soil. The other believes that further removal of water is essential. The fact is that neither protagonist possesses exact knowledge. There is a great need for the further development of the field research already initiated by Nicholson at the Cambridge School of Agriculture.

Despite all the difficulties and the conflicting opinions, a visitor to the Fenland is always impressed by the excellent condition of the open drains. Their straightness and clean-cut sides, as compared with those of the uplands, are as much a character of the landscape as the black soil and the unbroken vista. Drainage rates are very high in some fens, but the charge that drains are deliberately neglected in order to lower the rates, seems to be without foundation at present.

A curious character of fen soils which will be discussed more fully later, is the extreme dryness of the surface zone down to a depth of several inches. The difficulty of obtaining a moist seed bed is a very serious one, and crops may suffer severely from drought in the early stages of their growth. This has led many people, particularly those with market-garden interests, to consider overhead irrigation. The fact that the water would not require pumping, but could be siphoned over from the rivers which are at a higher level,

would seem to suggest that conditions were ideal for this practice. Unfortunately, such is not the case; for there is the extraordinary anomaly that, at the time of year when irrigation would be an advantage, there is not sufficient water in the rivers to provide for irrigation on any considerable scale. The water courses are very slow running and any reversal of the flow, when siphoning water out, would cause sediment to run back out of the main rivers and choke the stream.

The Shrinking Peat.

The fact that peaty land, when drained and cultivated, begins to shrink at a great rate for several years, and later at a steady rate of ½ to 1 inch per annum, may appear to be nothing more than an interesting natural phenomenon. It is no exaggeration to say that this phenomenon has had a greater influence on Fenland farming and on drainage than any other. The fate of the peaty fenlands is sealed and so long as they are kept drained and cultivated they will, as fens, gradually disappear.

The causes of shrinking are plain and inevitable. Undrained fen may contain up to 95 per cent. of water and 5 per cent. of peat, a startling but real fact. In the initial reclamation and draining a high proportion of the water is removed, and the peat settles for a few years at a great rate. Striking evidence may be seen in Denton Fen, Hunts., where an iron post (known as Holme post) was driven into the peat down to a foundation of blue clay in the year 1851 or 1852. In the first ten years the peat settled at the rate of nearly 5 inches a year and for the next ten at 3½ inches a year (3). Despite a period when the land has been derelict, the top of the post, which was once flush with the ground, is now about 11 feet above ground.

Apart from mechanical settlement, the peat is also disappearing through oxidation, due to exposure to the air consequent upon draining and cultivation. This is also inevitable, for the peat is organic matter, which is eventually dissipated like farmyard manure or any other forms of humus. It was, after all, only because of the waterlogged condition of the Fenland that it ever formed at all. The type of cultivation practised will influence the rate of dissipation, but even under grass this will, unless the pasture is allowed to degenerate to a swamp, be reduced only to about half.

The results of this shrinking, or wastage to use a more appropriate term, may already be seen over quite considerable areas. If the peat has disappeared down to a bed of clay, one will find quite good conditions still prevailing. The clay is, however, not level but has a more or less undulating surface, so that one has a mixture of soils under such conditions. It is likely that the residue of peat still left in the clay will persist for a considerable time.

In the areas where ridges and patches of clay have appeared, the drainage of the fields, by seeping of water through the peat to the open drains, is obstructed. A great deal of pipe drainage has been carried out in recent years, and much more will have to be done. On the clay areas, the type of farming practised may not need to be varied greatly. One finds, in fact, that those who are now farming light blowing peat, pray for the day when they will get down to the clay and when their erosion troubles will be over.

It is where peat overlies sand that serious consequences will arise, for the farm will then encounter all the problems of the light-land farming and, unless systems are changed radically, these areas may become rabbit warren. In such cases it would seem that there are possibilities for ley farming, though in one part of the Fenland, market gardening, with emphasis on salad crops, appears to be progressing on land where the peat has wasted down to gravel

The attitudes of the farmer and of the drainage engineer towards the wasting of the peat, contrast sharply. The former displays a cheerful complacence, while the latter views the consequences with grave forebodings. The engineer visualises the need for the lowering

of culverts and also for the greater power that will be required to boost water over the higher ground from the peaty hollows. The rivers will be still higher above ground level. Against all this, the farmer foresees the advent of stronger and more efficient pumps.

It is difficult to see how the gradual lowering of the peaty fenland can be avoided. Less intensive forms of cultivation might slow it up, but it is doubtful if the type of farming visualised could enable the farmer to pay his drainage rates. One cannot get over the fact that the fens are a wasting asset and, though several generations of men may farm them yet, they must eventually disappear. Whether we should exploit the land to the full and regard it as a wasting asset, or whether it should be conserved and exploited only in times of national emergency, is for the economist and the statesman to decide.

Management of Peat Soils.

The soils of the peaty fens provide many interesting phenomena which one does not meet on upland soils nor on peaty soils in other parts of the country. Many people have gained the impression that these soils, having been built up in hard water, are not acid and that they have a high lime content. There are, actually, quite extensive areas of acid peat which have apparently been formed in the old fen woods, while the remaining non-acid peat has developed under chalky water. Acid fen soils behave very differently from acid land in other parts of the country and the rules for the management of ordinary acid land do not apply. One may find good crops of barley growing in unrotted lumps of acid peat, and applications of lime to such land have, if anything, a harmful effect. One can reduce the acidity by liming, but unless it is done with discretion, and to a limited degree, the peat becomes very hard and dry.

Fen soils are commonly regarded as being highly fertile, but this is not entirely true. Heavy dressings of superphosphate were used in the past but apparently little more in the way of purchased fertilizers. It is an extraordinary fact, however, that on soils so rich that cereals lodge every year, potatoes will respond to dressings of sulphate of ammonia. In some parts, where, on theoretical grounds, one would expect a response to potash, there is no response in the shape of increased yields. There are areas, however, where this fertilizer is essential to the prevention of actual crop failure. In all areas one finds that potash plays a valuable part in restricting the growth of potato haulm.

There is a common practice throughout the peaty fenland of applying ashes, usually mixed in equal parts with superphosphate, as a fertilizer. Many people have criticised this practice as being without purpose, but there is no doubt that it does stimulate seedling establishment. The ashes are obtained from the cleanings from the open drains, which contain a high proportion of clay, but there is no doubt that the practice is a survival of the old system of paring and burning, carried out in the early days of cultivation of the peaty fenland. It is interesting to recall that Voelcker recommended the application of burnt clay to fen, mixed with the ordinary clay, and he appears to have noted the beneficial effects (4).

A great deal is written today of the benefits that accrue from the use of farmyard manure, composts and other organic manures. A school of thought has sprung up which attributes quite a number of the troubles of the fen farmer to the fact that he uses very little, if any dung. Eelworm in potatoes, and many other ills are attributed to this deficiency. If one attributes the benefits of farmyard manure to the organic matter of which it is mainly composed (for the inorganic nutrients can be supplied by chemical fertilizers) then it is difficult to understand how the addition of a dressing of dung, to what is already a bed of humus several feet deep, can be of any advantage.

An ingenious suggestion has been put forward that farmyard manure inoculates the soil with organisms that antagonise or prey upon such pests as eelworms. There is nothing

to support this idea, but it must be admitted that newly reclaimed fens, which have been waterlogged, cannot contain a normal soil flora or fauna. One finds crops of beans in a very poor state of development with a scarcity or even complete absence of nodules on the roots. The idea that dung will bind the soil is quite wrong, for peaty fen soils become so hot that organic matter loses its colloidal or sticky properties.

Water conditions in the peat are rather remarkable, in that one may have a dusty, bone-dry surface with hard dry clods down to a depth of a foot whereas, below a level of about 15 inches, the soil may be so waterlogged that the water can be squeezed out between the fingers, and the roots of wheat will not penetrate into it. This condition doubtless explains why wheat fails on some apparently dry fens, for it is a crop which, to use a popular expression, "cannot stand wet feet." These conditions are more common on the newly reclaimed fens than on the established ones, but they are evidence against the view that the fens are overdrained.

In certain years great trouble is experienced from blowing, and the phen menon is always worst in newly reclaimed fens, mainly because the soil is light and unsettled. Those who have no experience of these dust storms cannot appreciate their gravity. Newly drilled seed together with the fertilizer may be swept off a field, and sometimes a young crop may be carried away too. The open drains can be filled to the brim in a matter of a few hours, and many thousands of pounds of damage done in the same space of time. These dust storms are a great public nuisance, for the fine black dust penetrates through cracks in window panes and fouls dwelling houses.

The causes of blowing are very complex, but a proper understanding of the factors which contribute to this state of affairs would do much to prevent useless expenditure on palliatives. The trouble is not entirely due to the sweeping of high winds over a treeless plain, but primarily to the peculiar nature of the fen soil. The colloids in the fen peat have lost their binding properties and there is nothing, once the surface soil is dry, to hold it together in firm clods. The black fen soil becomes very hot on the surface, through the radiant heat of the sun, and this condition is intensified by the fact that peat is a bad conductor, and does not take the heat down readily.

If there is bright sunlight, as there usually is in the Fenland, the surface of the soil may reach a temperature of nearly 60 °F. on a bitterly cold day in February. The cold winds of early spring, passing over this warm surface, give rise to eddies which raise the dust in little whirlwinds; once it has lifted from the surface, it is whisked away by the wind to form a gathering cloud. It is therefore not the high winds which are primarily responsible; in the absence of eddies caused by cold air passing over a warm surface, the high winds would not raise the dust.

Claying.

No account of farming on the peaty fen would be complete without some comments on the practice of claying or marling. This was common in the past and the old hands at the job are referred to as claymen. Little was done during the period between the two wars, but there is some indication that mechanization may bring the practice into its own again. There can be no question that claying provides the solution to the problem of the prevention of blowing and any fenman will admit that a well-clayed field never blows, even if it is in the centre of a bad blowing area. Claying has other advantages, for it improves moisture conditions and general fertility. The colloidal matter in clay does not lose its binding properties under the burning heat of the sun.

The value of claying has been appreciated since the days when cultivation started. Wells expressed the opinion that a clayed soil did not suffer so much, either from extremes of temperature or severe spring frosts, as an unclayed one. An account by this author of

the claying of recently reclaimed bogland near Whittlesey Mere, appeared in the *Journal* of the Royal Agricultural Society in 1870 and describes how land, formerly yielding no rent, was let for 30/- an acre after claying. (5).

Several types of true clay occur in the Fenland and they are referred to collectively as "gault." Even geologists did not distinguish other clays from the true Gault and the old claymen may be excused for their confusion. There is one type of clay, or more correctly speaking a type of silt, which is found at comparatively shallow depths in the peat and which is known as "Buttery Blue." This has a certain amount of fertilizing value apart from its binding properties, but it is not so lasting in its effects, and is not so valuable in the long run, as is generally believed.

The labour of claying must have been colossal. It is considered so today, even with the aid of excavators, tractor-drawn vehicles and bulldozers, but the old claymen dug the clay and spread it by hand, at rates of 100 to 200 tons per acre. The effects of real Gault were stated to last for 50 years and, this being the case, the cost was worth while. The problem to-day is to reduce the cost to a level that will make the operation economic; it is claimed that it can be done mechanically for £9 per acre. There is certainly good scope for research in this direction and also to find sources of clay in close proximity to the sites requiring claying. Local knowledge is lamentably lacking as to the sources of clay, and good material has turned up in many unexpected places.

The Future of the Fens.

Many of the difficulties facing the fen farmer appear to be unsurmountable and one could paint a very gloomy picture of future prospects. The attitude of the typical fenman may be described as stoical. He has mastered so many difficulties in the past, and become so inured to hardships, that he displays a steady confidence. It is obvious that he cannot continue with his present narrow rotations and the diseases which are associated with them. But the possibility of a change over to a greater variety of crops will depend on economic circumstances. It is to be hoped that any encouragement that may be given will be towards a diversity of crops rather than towards a narrow concentration on two or three.

It is fashionable to-day to regard ley farming as a panacea for all ills. Many people have asserted that it would be the salvation of the fens, and some have gone so far as to recommend large-scale dairy farming. A moment's reflection will show the futility of the latter suggestion. The capital outlay on buildings alone would be enormous. Every field would have to be fenced substantially to prevent not only the straying of cattle, but death by drowning in the open drains, and it is difficult to see how returns from any form of stock farming would stand the high rents and drainage rates.

The most critical problem is that of housing, roads and water supply. It comes as a surprise to people who have only heard of the fens to know that the water position for livestock, for spraying and most particularly for household use should be so critical. The days have gone when farm workers and smallholders will live in hovels miles away down a muddy drove, and the position will have to be remedied by one means or another. It is a pity that concrete roads have had to be laid in war-time, at great expense and without any preliminary experiment. Lessons learnt on the battlefields may do much to solve the road problem in the fens.

It should be borne in mind, by those who question whether it is worth while saving the situation for a section of the farming community who find themselves in difficulties through natural forces beyond their control, that it is not only the farmers who will suffer if the fens go back to primæval swamp. The nation will lose a rich larder in times of emergency and

a large community of traders and professional people, whose living depends on Fenland agriculture, will lose their means of existence.

ACKNOWLEDGMENTS.

I am indebted to the Executive Officer of the Isle of Ely War Agricultural Executive Committee for the analysis of holdings in that county in size groups.

G. H. BATES.

FARM INSTITUTE,
PENKRIDGE, STAFFS.

References

1. DARBY, H. C. "The Draining of the Fens." *Cambridge University Press.* 1940.
2. *Ibid.*
3. FOWLER, G. "Shrinkage of the Peat Covered Fenlands." *Geog. Journ.* LXXXI, 149. 1933.
4. WELLS, W. "On the Treatment of the Reclaimed Bogland of Whittlesea Mere." *Journ. R. Agric. Socy.* 2nd Series VI., 203. (1870).
5. *Ibid.*

SEED POTATOES

with special reference to English Seed Potato Production.

THERE could be no better time than the present to pay tribute to the humble potato, which has played so important a part in history. For the past 100 years it has influenced man's destiny, but the greatest test of all came at the outbreak of war in 1939. The amazing production of this crop on which we have depended so much to save us from starvation, is not the least of the achievements of the last six years. Behind this great effort were the growers, who have every reason to be proud of their response to the call for maximum production of this vital foodstuff.

Science and Practice : Virus Diseases.

Maximum production demanded immense effort on the part of all connected with the industry, and the link between science and practice was strengthened as the necessity for increased production became more acute. One outstanding fact which emerges at the end of the war is that potato growers have been stimulated to search for further knowledge and in consequence many of them have become 'virus-conscious.' It was fortunate for this nation that, as a result of research, it was known that the cause of degeneration in potatoes was contamination with plant viruses and not senile decay. This knowledge, now put to practical use and advantage throughout the whole country, has been of the first importance to the potato crop in recent years, and has given a very real meaning to the slogan 'Healthy Seed for Healthy Crops.'

It is well at the outset that the reader should become familiar with the terms 'healthy' and 'unhealthy' as these are freely used in connection with seed potatoes and seed certification schemes, they relate only to the absence or presence of virus diseases in the growing crop.

The importance of healthy seed in potato culture has been shown by the performance of seed potatoes certified under the various health certification schemes operating in Great Britain, and such crops have been the basis of maximum production.

These schemes form the basis of practical field demonstrations which are laid down each year at the Midland Agricultural College for the purpose of placing actual evidence before the growers. Visits to the demonstrations provide an opportunity to discuss, and receive advice on, each grower's own particular problems. The trade has expressed the desire to keep in close touch with these practical demonstrations ; merchants attach most importance to (*a*) the plots showing the effect of the spread of virus diseases in the field, and (*b*) the facilities for training in the identification of potato varieties.

For many years scientists have been investigating the reasons why potato stocks from northern districts lose much of their vigour and cropping power when grown once or twice in the milder English climate. Of the first importance, as stated, was the discovery that degeneration was due to virus diseases, the symptoms of which are shown in the foliage and the result in the yield. The main virus diseases with which every potato grower should become familiar are leaf-roll and severe mosaic, whose presence in a crop is shown by dwarfed, crippled-looking plants. The important points to be stressed about these diseases are firstly that they are infectious and are spread in the field during the growing season from infected plants to neighbouring healthy plants mainly by aphids (greenfly); and secondly that the tubers saved from plants already showing the distortion of virus infection will produce plants in the following year which are not only more feeble and crippled but will act as dangerous sources for the spread of virus to surrounding healthy plants. It is difficult

for the uninitiated seed potato grower to realise the full extent of the spread of virus diseases in the field until he has tried out methods to control contamination, as normal healthy plants exposed to infection do not as a rule clearly show visible signs of infection in the current year.

It is no exaggeration to say that the crop lifted from infected plants can be less than one-half of that obtained from normal healthy ones. Costly manuring and cultivations—or the old idea of a change of land—are of no avail as a means of overcoming the effects of virus infection, but once it is understood why healthy stocks rapidly " run out " or degenerate, the grower can direct his attention to methods of control.

It is not generally realised by English growers that in pre-war days only sufficient seed was imported every year from Scotland and Ireland to plant approximately one-third of the total acreage grown in England and Wales; the remaining two-thirds of their requirements being provided from their own crops. This latter supply was, in the main, saved from the ordinary ware crop, the seed size tubers being retained and planted in the following year, often with disastrous results in yield. No method is known at present for distinguishing virus-infected from healthy tubers. It is most satisfactory to note that the old practice of buying seed on the basis of an examination of the tubers alone, is fast disappearing, and the gospel that it is not enough merely to save potatoes from *any* ware crop but that crops must be specially grown for seed (or at least must be grown under the conditions expressed in the health certification schemes) is becoming widespread throughout England and Wales.

Seed potato growers in Scotland, Ireland and the higher districts of England and Wales have the advantages of a scarcity and of a restriction of movement of aphids in their respective countries; the cold climate is not conductive to high aphid population and the heavy rainfall and strong winds restrict movement.

The commonsense of seed production has been embodied in the certification schemes established by the various Departments of Agriculture. Under these schemes crops are inspected and certified as suitable for seed purposes. In order to understand the full significance of certified seed it is well to be acquainted with the terms used, and the following is a brief explanation :—

Leaf-roll : affected plants are usually stunted and lacking in vigour, have a stiff appearance and rattle when shaken ; the leaflet margins show a rolling upwards and inwards, becoming funnel-shaped and brittle.

Severe Mosaic : the plants are dwarfed and, as the season advances, the weak stems tend to droop. This is followed by total collapse of the plants which then sprawl over the drills ; the leaflets have a puckered appearance and are smaller than normal with yellowish-green mottling.

Wildings : these are small bushy plants with numerous very thin stems (in some cases there are dozens of branches) and a large number of underground stolons. The leaflets have a tendency to become round and there is a marked reduction of secondary and primary leaflets, usually resulting in one roundish terminal and one or two pairs of inconspicuous leaflets. The crop generally consists of numerous small tubers ranging from seed size to those like peas, the latter size predominating.

Bolters : this type of plant, like the wilding, can also cause a certain deterioration within a crop. They are much taller and coarser plants than the normal ones, with very marked strong, upright branching of the stems ; they generally flower more freely, are later in maturing and if allowed to mature produce coarse tubers.

' *True to type* ' : the figure under this heading is an index of the purity of the stock. All plants of other varieties than that of the crop as entered for inspection are known as " rogues " and 99.5 per cent. true to type means that there were 0.5 per cent. or less of rogues in the growing crop.

The virus content, purity, etc., of a stock is determined after careful and cautious inspections have been made *whilst growing* (twice for Stock Seed and once for stocks graded 'A' and 'H'), and the following classes or grades of certificates are issued as a result of these field inspections :—

'*S.S*' (*Stock Seed*) indicates crops 99.5 per cent. true to type containing no bolters and not more than 0.25 per cent. of virus diseases and wildings, including not more than 4 plants per acre affected with leaf-roll or severe mosaic, or wildings.

'A' *Certificate* is issued to a crop 99.5 per cent. true to type which contains not more than 1 per cent. of readily visible virus diseases, of which not more than 0.5 per cent. may be leaf-roll, severe mosaic or wildings. The amount of mild mosaic present in a crop is taken into consideration at the time of inspection.

'*H*' *Certificate* is given to a crop 99.5 per cent. true to type and containing not more than 3 per cent. of leaf-roll, severe mosaic and wildings.

It is interesting to discuss the potentialities of the above-mentioned grades of seed.

Stock Seed certificates have in the past been issued only in Scotland and Ireland but this year they have been embodied in the English health certification scheme under conditions comparable to those obtaining in Scotland and Ireland. It will be realised that seed from a crop awarded a Stock Seed certificate is of superior health as far as virus diseases are concerned ; it is also a high-priced commodity and should, therefore, be used exclusively for seed-production purposes. It is deplorable that hundreds of tons of seed of this superlative health grade are planted annually for the production of ware crops in England. It is the type of seed which should be directed into channels where it can be purchased and grown for *seed* with great benefit to those growers whose geographical situation is ideally suitable for super-seed production, *i.e.*, certain districts in the north and west of England and Wales. Incidentally, the issue of Stock Seed certificates in England and Wales is restricted to crops grown in those districts. Many English growers apparently do not appreciate what labour and forethought have been expended in its production, for producers of Stock Seed are enthusiastic, take an intense interest in their potato crops, and are very zealous in their seed-growing efforts.

'*A*' *Certified Seed* stocks are the popular class of seed for production of 'H' grade in the following year. Their virus content is low and when grown with care and good planning should produce excellent crops. As in the case of Stock Seed certificates, 'A' certificates are restricted in England and Wales to crops grown in certain districts in the north and west of England and in Wales.

'*H*' *Certified Seed* stocks are grown under the same cultural conditions and planning as the 'A' stocks, but as their virus content is up to 3 per cent., the resulting crop should be grown exclusively for *ware* production in the following year. They are perfectly suitable for this purpose, provided that the land is suitable for potato culture, is well manured and cultivated, is free from eelworm infestation and that a suitable choice of varieties is made.

Uncertified Seed. It should be pointed out that crops resulting from English 'H' class of seed are not inspected again or admitted into a certification scheme for seed purposes in the following year. These stocks automatically become ware or uncertified seed, and any grower purchasing this type of potatoes does so at great risk of obtaining poor growth and much reduced yields. Progressive ware growers can, nevertheless, do much towards producing their own uncertified seed which may be very suitable for ware production in the following year, and has a great advantage over seed saved under the old haphazard methods.

A study of the modern system of seed production shows that the production of good seed in England and Wales is not a complicated affair. Successful potato growing can be

learned from the methods adopted by the Stock Seed growers, and these also apply, with certain modifications, to the ' A ' and ' H ' seed producers. The main features are :—

(1) The fresh seed planted should be from an officially certified stock. (In the case of Stock Seed it is of interest to note that there are many instances where a stock has been built up from a single healthy plant).

(2) The crop must be grown in isolation from any other potatoes of doubtful or unknown health. The minimum isolation distance is 10 yards where surrounding crops are of a high standard of health ; no certificate will be issued in respect of a crop within 50 yards of other potatoes which show evidence of substantial virus infection. It will thus be seen that isolation is of primary importance to the seed producer, and forethought as to the actual growing area at planting time is essential, special attention being given to the possibility of contamination with virus diseases from potato crops likely to be growing on neighbouring farms ; fences are no barrier to aphid movement.

(3) No danger zone should be created by the grower himself. The temptation to fill out ' that last half-acre ' with once-grown seed of unknown health should be resisted, as it will probably preclude the crop from being considered fit for seed purposes under the certification scheme. Many excellent crops grown from certified seed have been absolutely ruined for further seed purposes by the introduction of virus into the field in this way ; therefore these vacant areas should be planted up with crops other than potatoes. Old clamp sites are equally dangerous and special attention should be given to the clearing of such ground.

(4) Precautions should be taken to eliminate possible contamination *within* a seed plot early in the growing season, that is, as soon as a fair amount of foliage has developed. Severe virus symptoms can be seen at an early stage of growth and it is important that such infected plants be removed before tubers are formed, so that there may be no risk of leaving tubers behind. Infected plants left to grow on serve only to spread infection amongst the healthy plants surrounding them. As high-grade certified stocks possess a certain guarantee of health, it is clear that the work of removal of infected plants within a crop grown from such a stock is reduced to a minimum, but a crop containing more virus-infected plants than the standard fixed for certification presents a risky problem in the matter of removal, especially in the milder climate of England where virus diseases are spread very rapidly by flying aphids. In such cases it is wise to consider the crop as suitable for ware production only. All variations, such as wildings and bolters, should be rogued out during the growing season and whilst identification of the different types is possible.

(5) In seed production ground-keepers (or self-sets), *i.e.*, potatoes left in the ground from previous crops, must not be overlooked, as they can be a very serious source of infection if derived from a crop which contained a high percentage of unhealthy plants. These become centres of distribution of infection within the seed-growing area; therefore one of the main essentials in first-class seed production is to adopt as long a rotation as possible. The advantage of a long rest or break between successive potato crops cannot be over-stressed; it is very desirable not only for the purpose of clearing the land from ground keepers but for the safeguarding of future potato crops from serious pests and diseases.

In brief, the essential points in the production of healthy seed are—planting of certified seed in isolation, good planning of the potato area at planting time, freedom from ground-keepers and a long rotation.

Literature can be obtained from the Ministry of Agriculture explaining the conditions of the scheme for the inspection of growing crops of potatoes, and much valuable information is given in the Ministry's Advisory Leaflet No. 139, ' Potato Virus Diseases.'

Varietal Tests.

Despite the encouragement given to seed potato growing through the certification schemes, many growers are still unfamiliar with other aspects of potato culture.

The perfect potato variety does not exist but many now popular varieties have some qualities which go to the make-up of good and desirable kinds. The hall-mark of a good variety is that it must stimulate consumer's preference through its appearance, shape, size, colour and eating quality, and incite interest amongst growers by its cropping power, freedom from second-growth (this refers to cracked or knobbly outgrowths, in some cases accompanied by hollow centres) immunity or relative immunity from diseases, good keeping quality, and ease of culture.

To appreciate fully the qualities of those varieties at present in commerce it is necessary to know what growers have been spared in the matter of undesirable kinds. It was discovered 37 years ago that certain varieties were immune from Wart Disease, and it was obvious that raisers should be encouraged to produce immune sorts. To prevent any misunderstanding, it should be made quite clear that in the same way that the term 'healthy' is applied to virus-free seed, similarly the term 'immune' is used to denote wart-resistant varieties only.

The writer has had the privilege of being associated with the testing and identification of potato varieties for the past 25 years. From 1920 the Ministry of Agriculture's potato trials and demonstrations were conducted at the Potato Testing Station, Ormskirk. In 1940 the work was transferred to the Midland Agricultural College, where it has latterly been extended to include the training of personnel employed in the inspection of potato crops.

The work necessitates much detailed recording and close co-operation with potato breeders, who have given every assistance in supplying information on the pedigrees of their respective seedlings. Details concerning all varieties have been preserved and these records are now of historic value. They also include reports made on a number of foreign varieties. A full description is recorded covering the characteristics of the whole plant, such as the habit of growth ; colour and formation of the foliage in minute detail ; flower colour and occurrence ; tuber shape, skin and flesh colour ; depth of eyes ; appearance of root system ; sprout colour and development ; maturity and other special features of the variety. Details are also kept of the yield and type of crop produced and, in addition, the reaction of the variety to various diseases. This, as a whole, forms a permanent record for the future identification of the variety. Seedlings entered for the official trials are examined by the Potato Synonym Committee of the National Institute of Agricultural Botany, whose function is to determine whether a particular variety is considered distinct or synonymous with an existing kind.

A museum of varieties, which as far as possible contains samples of all those in existence, some of which have been in cultivation for more than a hundred years, is planted each year and is invaluable in checking the distinctness or otherwise of the seedlings entered for test. Close contact is also kept with the Scottish and Northern Irish potato trials by interchange of varieties and reports.

At the inception of the trials the work on the resistance and susceptibility of varieties to Wart Disease brought to light the chaotic position in regard to the naming of potato varieties. For instance, the variety Up-to-Date was masquerading under 200 different names and there were nearly 100 names each for Abundance and British Queen. To make the situation even worse, stocks bearing these 'fancy names' were often offered to the public at an enhanced price over that of the correctly-named stock. It is interesting and gratifying to review the present situation. The practice of placing potato synonyms on the market has been abolished, and credit for this is due to the Potato Synonym Committee working in conjunction with the authoritative bodies governing the work of the trial centres.

The trade now willingly accepts advice regarding correct descriptions of potato varieties, and uses the trial centre as a bureau of information on potato varieties and problems.

All this work has a very direct and important bearing on certification schemes, as the facilities afford scope for the benefit of people whose work entails identification of varieties, and it is the fundamental feature underlying the qualification of a second crop classed as 'true to type.'

During the quarter of a century that official Wart Disease Immunity Trials have been carried out by the Ministry of Agriculture nearly 12,000 plots of potatoes have been laid down for field tests, and in addition approximately 3,000 samples have received laboratory tests. Up to 1927, the test for wart disease was carried out solely on land infected with the disease, but dry seasons were not favourable to the development of the disease and the test, therefore, was usually of two-years' duration. In 1928 an indoor method of test was developed, whereby results could be obtained within 28 days and, whilst this is now the recognised official method of testing for immunity from Wart Disease, all seedlings entered for trial are grown in field plots, and their growth characters recorded.

The benefits arising out of these trials have been enormous. Undesirable characteristics are frequently disclosed at an early date and seedlings showing such are readily discarded by the breeders. As a result there have been notable changes in the characters of the newer kinds; purple-skinned varieties have practically disappeared, deep-eyed kinds are now in less favour, varieties giving coarse misshapen tubers coupled with long stolons and fibrous roots and a predominance of seed, or producing haulms of sparse weak foliage, are not encouraged.

The raising of new varieties is very largely the work of an altruistic group of people whose co-operation in discarding worthless types has contributed much towards avoiding later disappointment. The fact that a variety survives this process of elimination in its early years, and is eventually added to the list of Approved Immune Varieties, does not necessarily mean that it will become popular. The extreme conservatism of the average grower has to be encountered to be believed, and only recently have certain varieties which completed their tests 8 to 9 years ago been generally adopted. Potato growers should make an attempt to keep themselves informed of new varieties, should endeavour to try out some of them, even if only in small quantities at first, and so find those which suit their type of farming and market requirements.

There have been many disappointments in the past. A variety has been taken up early in its career only to be dropped within a short time, and it is no undue criticism of the grower to state that many new kinds have not been given a fair chance. The care with which a new variety is built up by raisers or introducers is unbounded, and as far as possible healthy seed is distributed. This is often purchased and planted—in sublime ignorance—adjacent to a crop grown from unhealthy once-grown seed. A special appeal is made for new varieties to be given every opportunity to show their value and, first and foremost, they should be grown under conditions suitable for good seed production, such as those laid down in the certification schemes.

An interesting lesson lies behind the entry of Arran Pilot into commerce. This early variety has fulfilled its first promise as one of outstanding merit (as is shown by war-time acreage figures) but it was almost lost to the world at the critical period of its introduction. Small stocks were purchased by certain enterprising growers but unfortunately they were grown adjacent to some once-grown potato crops containing severe virus-infected plants. Arran Pilot is very susceptible to virus diseases and when this seed was planted again in the following year, the results were disastrous. At this stage the variety seemed doomed, but facts concerning the spread of virus diseases in the field were then becoming known in trade circles, and the raiser of Arran Pilot decided to persevere with this valuable early. Fresh

Scotch seed of a high standard of health was supplied to several individual farmers with the stipulation that the seed should be grown in isolation and under conditions favourable to the production of a healthy crop. This practical effort demonstrated that a variety very susceptible to virus diseases derives even more benefit than other varieties from good growing conditions. Nevertheless, unless the grower is situated in a district considered ideal for super-seed production, it is advisable to purchase fresh certificated seed of Arran Pilot each year.

No attempt is made by any authority to prohibit or restrict the marketing of new varieties, whether these are recommended as worthy or not, but a variety receives official recognition if it proves to be immune from Wart Disease and is distinct from any existing variety. When the raiser or introducer of such a variety has named it and given an assurance that it is his intention to put it on the market, it is added to the Ministry's list of Approved Immune Varieties. A few valueless varieties have been introduced into commerce from time to time but it is interesting to record that no wart-susceptible variety has been put on the English market for many years.

The more recent trend in potato breeding is towards the raising of disease-resisting varieties. None of the commercial varieties of today is absolutely immune from Blight although a few show some degree of resistance. Certain wild South American strains possess a very high resistance and these are now being used in potato breeding in an endeavour to impart some of their special features to new kinds suitable for the potato industry generally. It is hoped that some promising blight-resistant varieties will emerge from this work.

Other desirable features, such as resistance to Dry Rot, have not as yet received special attention from breeders, and it is to be hoped that the scope of all breeding work will be extended to cover this and other resistant qualities in the future.

Seed Storage

Care in handling seed is of primary consequence. The sprout of a potato is one of its most vulnerable parts, especially in the case of early varieties. The boxing, or chitting, of early kinds should be carried out under light, frost-proof conditions for the purpose of producing strong sprouts, thereby hastening earlier bulking of the crop at the opening of the season. This method of storing seed is also a safe-guard against misses occurring in the field through Dry Rot, Blight, etc., as these troubles can often be detected and affected tubers removed.

Misses in the field can also be caused by such harsh treatment as is occasioned by 'de-sprouting.' One shudders to think how much man-handling the seed potato is expected to stand before it is finally planted and covered up. Many tubers have their sprouts knocked off during riddling operations at the clamps, they sprout again in the bags or in the purchaser's clamps, only to be de-sprouted once more before planting. This latter de-sprouting is often due to the breaking off during planting operations of the long weak shoots which have arisen in the absence of proper chitting accommodation. Tubers subjected to such maltreatment have more or less exhausted their capacity to grow, and many merely soften and decay in the soil with consequent gaps in the field.

The crop of an early variety intended for seed should be lifted with great care and if possible boxed immediately. The practice of leaving seed in the open field to be 'greened' should be followed with great caution ; a hot sun pouring down on the new tubers, in many instances for several weeks, is certainly not good, and often results in excessive scorching of the delicate skin coupled with rotting of the tubers. Here another fallacy can be exposed —the action of 'greening' has no effect whatsoever on the subsequent health of the crop ; it is merely a means of producing the "setting" of the skin similar to that which occurs before lifting mature maincrops, that is the skin should not flake by ordinary pressure of

the fingers. The important point about the lifting of seed early in the season is that it is an attempt to escape virus contamination later in the season.

Virus-free seed should be protected against possible virus contamination in the store, as these diseases can be spread by greenfly indoors from sprouts produced on virus-infected material in the same way as they are transmitted in the field, thus often polluting healthy shoots even before planting time. The periodic fumigation of the potato store is a wise precaution.

Size and Treatment of Seed.

Since there is a wide range in the possible costs imposed by the seeding rate per acre, and often a shortage of supplies owing to an increased demand for seed of high quality, it becomes necessary at times to utilise the available seed to the fullest advantage.

The ideal size of a seed tuber is one which will go through a 2 in. riddle but stays over a 1¼ in., in other words about 2-3 oz. in weight. Large tubers --those which are of a dressing over a 2 in. riddle—planted whole may give a similar total yield but the crop will contain a higher proportion of small tubers—a very important advantage to the seed-grower but a disadvantage where the crop is intended for ware. The use of chats or 'thirds' on the other hand results in a crop containing fewer potatoes but of larger ware size.

To receive large size seed or to be left with a stock of ware on hand from a healthy crop often constitutes a problem. It is obviously not an economic proposition to plant whole large tubers for the production of a ware crop, so the cutting of these for that purpose may be regarded as the most efficient method of seeding, provided cultural conditions are suitable. On the other hand, the value of the crop intended to be saved primarily for seed purposes depends on the actual yield of tubers of the desired size; therefore the planting of large uncut tubers should be considered. The actual effect of cutting a tuber is not generally understood and a brief note will perhaps help growers to appreciate advice on how to obtain the best results from the use of cut sets.

When the potato tuber is cut, sap is released from the cut cells and the living cells below the cut surface begin to divide and produce a layer of callus (wound healing tissue). If the cut surface is to heal over successfully, the layer of callus must be continuous over the surface and free from cracks through which disease organisms might gain entrance. A continuous protective callus can only be formed under moist conditions and it is essential, therefore, that immediately after cutting the tubers should be maintained in a moist atmosphere; so that the cut surface of the tuber does not dry out and produce an uneven layer of callus.

In order to provide the moist conditions necessary for perfect healing of the cut surface, certain rules should be observed. Cutting should take place in the shade, as sun temperatures are too high for this treatment of seed and will cause injury even if they are exposed even for a short time only. Immediately on cutting, wet cloths or sacks should be thrown over the sets and left for 24 hours, after which time the sacks may be removed and the sets can be planted at once, or they may be kept in a reasonably cool shady place until required. If the callus is patchy, showing very dark grey or black areas, or is cracked as a result of exposure to the sun or dry conditions during or following the cutting operation, then rotting may be expected with consequent misses in the field. The planting and covering up of sets in the field should be almost simultaneous, and every care should be taken to see that they are not exposed too long in the furrows. This treatment is strongly recommended for all types of cut sets, whether large ware tubers halved or for the preparation of potato 'chips' or eye pieces.

Sets cut according to the above-mentioned conditions have been kept for many weeks and provided good seed pieces at planting time. The best results from the use of cut sets

are obtained by planting as soon as possible after rain. The seed piece requires a fine tilth and moist soil conditions in order to make as quick a start in growth as possible. The tubers should be cut lengthwise and great care taken not to damage the eyes or sprouts. The same cultural conditions are desirable for success in the use of chats or 'thirds,' and neither these nor cut sets are recommended in districts where dry soil conditions prevail, since drought retards quick development. The aim in both types of seeding is to get the root system developed rapidly so that the plant may soon become independent of the small seed piece.

Other Diseases and Problems.

No domesticated plant is more subject to parasitic or fungus diseases than the potato, and some of these still remain more or less a mystery ; some are of little economic importance but others may seriously affect or almost completely destroy the crop. Investigations are proceeding on many of these problems and we hope for an early translation of the successful results of research into practical methods of control.

Dry Rot of potatoes causes serious losses during the late winter and springtime, usually after the stocks are delivered into the seed store. Most early and second-early varieties are susceptible to a greater or lesser extent. Amongst maincrops outstandingly susceptible varieties include Doon Star, Majestic and Redskin. Losses in seed can be controlled by dipping in organic-mercury solutions at lifting time but the difficulties inherent in the use of a wet treatment have prevented widespread adoption of this control measure. Work is now in progress to develop an easier method of control which could be used on a large scale.

Blight is perhaps the most destructive disease affecting the potato crop and precautions should be taken to prevent undue loss in the clamps. There is danger of general infection at lifting time if the foliage has not completely died down and still carries the active spores of the fungus, as these fall off into the soil and in this way infect the tubers during lifting operations.

The first symptoms of blight on the tubers are small reddish-brown spots or blotches on the skin, and the infection goes deeper into the tuber from four to six weeks after lifting. If the crop is harvested under wet conditions (which are very suitable for the spread of the disease) severe infection of the tubers often occurs and develops quickly with the result that such tubers become reduced to a foul-smelling mass.

Blight is not known to spread from tuber to tuber during storage, but there is ample evidence that the spread of wet rots to sound tubers is due to the heat developing from blighted tubers.

The first control measure is to reject all infected tubers at planting time. To guard against Blight in the clamps growers are urged to destroy or burn off the tops when Blight becomes prevalent in the crop—or wait until at least ten days after the complete death of the top. Advantage should be taken of any fine weather to lift under dry conditions, and infected tubers found at lifting time should be destroyed.

Potato Eelworm is the cause of the condition known as 'Potato Sickness' and the attacks are fairly widespread throughout the country. The pest is readily carried in the soil adhering to seed potatoes and, therefore, there is grave danger of introducing it to fresh land. The symptoms are yellowish plants, lacking in vigour, which die off before their normal time. An examination of the roots reveals the presence of small white or light brown cysts on the fine rootlets of the plant. As these reach maturity they turn to dark brown and fall off into the soil where they await to attack the next potato crop, which in its turn builds up the eelworm population. Where a short rotation is practised potatoes rapidly cease to be paying proposition on such fields. No effective method of destroying the cysts on a field scale has been discovered. Where eelworm infestation is present, it is

advisable to keep potatoes out of the rotation for five or more years, the longer the better, as this is the only control known at the present time. After the long rest from potatoes the number of viable cysts becomes much lower, falling to a level considered safe for planting.

In the interests of good husbandry growers should be continually on the watch for this pest, and once again the importance of a long rotation cannot be over-emphasised. The seriousness of the spread of eelworm is such that crops found on inspection to be suffering from the effects of serious infestation with this pest are classed as unsuitable for use as seed.

The Future.

The foundation of a good crop is laid if sound tubers from a healthy stock are planted and good cultivations are carried out, not forgetting that the potato responds to generous manuring. Nothing will overcome the evils of using virus-infected seed or the effects of planting on eelworm-infested land.

Concurrently with the passing of war-time conditions, the potato industry will have to prepare to adapt itself again to the changed conditions of peace-time production. The enormous quantities produced during war-time have enabled the country to be self-supporting in potato supplies but some adjustments will be necessary in the years to come to make quality as well as quantity the aim of all. The real need is for a few varieties of acknowledged merit on which the grower can concentrate his efforts, together with the opportunity to put into practice much that has 'set him thinking' as a result of the knowledge now available on potato culture generally and the experience gained by the difficulties of feeding a nation at war.

N. McDERMOTT.

Midland Agricultural College,
Sutton Bonington,
Loughborough

THE FUTURE OF "FARMING CLUBS"

THERE is general agreement throughout the country that agriculture must not again be allowed to fall into the state of decline prevalent before the war, but that a healthy and prosperous agriculture must play its vital part in a balanced and sound national economy. This end can be attained only if British Farming reaches a high level of efficiency. The agricultural community must therefore be well trained, not merely in the proper execution of farm operations, but also in the practical application of the proved results of research work. Further, there is need to promote understanding of the economical and social aspects of farming.

The writer, in the course of his work as Secretary of one of the recently established 'Farming Clubs,' has been struck, on the one hand, by the thirst for knowledge on the part of both young and old and, on the other, by the generally recognized need for a greater degree of co-operation and more social intercourse.

If we are to supply the required knowledge and to remedy the present lack of co-ordination in this field, to which the report of the Luxmoore Committee refers, we must build up a new organization for Adult Education in the rural areas. Such an organization should be a voluntary association of members of the rural community. The writer believes that the 'Farming Clubs' which have lately been brought into being can be developed into the instrument that is needed. Part 'A' is a short report on the present position of the self-education movement in rural areas in this country. Part 'B' discusses the aims, objects and organization of 'Farming Clubs' and sets out tentative proposals for the framework of an organized rural community with 'Farming Clubs' (or 'Farm Communities' as it is suggested they might more appropriately be called) as its focal points.

PART 'A'—THE PRESENT POSITION.

1. IN ENGLAND.

(1) *Agricultural Societies.*

Various movements to promote self-education started in England more than a century ago and included some by the farming community; numbers of Agricultural Societies and Farmers' Clubs were then founded. Some of these associations were national, some regional, while others served only a particular county or smaller locality.

The first of the national societies were the Highland and Agricultural Society of Scotland (founded 1784), and the Royal Agricultural Society of England (1838). Both societies fostered the diffusion of knowledge, firstly by holding annual exhibitions, secondly by organizing lectures and discussions on questions affecting agriculture, and thirdly by publishing Journals.

An outstanding example of a regional organization is the 'Bath and West and Southern Counties Society' established in 1777 for the encouragement of agriculture, arts, manufacture and commerce. In addition to the holding of its annual show the Society carries on experimental work at various stations in the region. It also holds discussions following lectures on topical agricultural subjects, and publishes a Journal.

In all the English and Scottish counties there are County and other Local Agricultural Societies which, however, have increasingly concentrated on the single activity of holding an annual agricultural show. The membership of all these organizations includes all classes of men connected with farming—landowners, land-agents and merchants as well as farmers, and in some cases also men who had no specific contact with land. After 1912,

and in connection with County Agricultural Education, Agricultural Discussion Societies were started in some counties—notably in Devon—and proved very valuable in stimulating the interest and co-operation of the farmers.

(2) *Discussion Groups, Farming Clubs, etc.*

The latest development in agricultural self-education is based on the same idea of furthering agricultural progress by disseminating knowledge, and by developing co-operation. But the new movement tries to go deeper and to reach all connected with the farming industry. The following are a few representative examples of modern organizations.

(*a*) *Discussion Groups and Farming Clubs.*

Just as some of the County Organizers before the war tried to reach the farmers through Discussion Societies, so many of the County War Agricultural Executive Committees have inaugurated local Discussion Groups in their counties. These Discussion Groups pass under different names in the different counties.

In Hereford they are called 'Discussion Groups' ; in Oxfordshire and Berkshire 'Farming Clubs' ; in Buckinghamshire 'Agricultural Clubs' and in some other counties 'Farmers' Discussion Clubs.' In Hampshire they are called : 'Grow-more Clubs.'

Worthy of note also is the progress which has been made with the formation in the Vale of Evesham of specialised 'Horticultural Discussion Clubs.'

The objects and structure of all these Clubs or Groups are essentially the same. The rules of one particular club may be cited as an example :—

Its object shall be to promote and encourage good farming and the good neighbour outlook.

To achieve this object the Club shall :

(*a*) promote the discussion and the exchange of experiences among the members of every-day farming problems so that all may benefit ;

(*b*) promote the discussion of new ideas and techniques as they are brought to the notice of the farming community, and of any experience of their application ;

(*c*) promote closer co-operation amongst members in the use of implements, machinery and labour ;

(*d*) promote interest and enthusiasm in rural craftsmanship ;

(*e*) arrange small trials and demonstrations on individual farms in the club area of such new methods, new implements, varieties of seed, etc., as the Club thinks may prove beneficial in its area ;

(*f*) arrange visits to farms of club members (and occasionally to other well-known farms outside the area) and to Agricultural Colleges, Farm Institutes and similar Institutions ;

(*g*) take advantage of the free advisory services available in the form of talks by experts on farming problems.

Indoor meetings, generally once a month, are held from October to March. The most common evening meeting has been one at which a specialist (either farmer or technical man) has given a talk for about one hour with a view to initiate a "free-for-all" discussion.

Summer meetings have usually taken the form either of 'Farm Walks' by individual Clubs in the evening, or of organized visits by members of several Clubs to Research Stations, College and Institute Farms.

In most counties membership of these Groups and Clubs is open to farmers only, but in others farm workers and others genuinely connected with the farming industry are admitted also.

(*b*) *Pools and Mutual Aid Groups.*

Owing to war-time conditions farmers have found it advisable to pool their resources with their neighbours. The first of such parish pools for machinery and labour were formed in Buckinghamshire and the scheme proved a striking success. In 1943 it operated in 22 parishes and covered 60,000 acres. It enabled farmers to get their ploughing, cultivations, etc., done at the right time by making maximum use of available resources.*

From the machinery pooling scheme have grown other activities. Parish 'pools' have arranged many technical and other farming discussions and other activities are being

*A number of the Pools have joined together to form the Bucks. Farmers' Parish Pools Ltd., which is registered under the Friendly Societies Acts

considered. As an example of such the Water Stratford (Bucks.) Machinery Pool may be mentioned. This was the first Pool in the country to deal with labour as well as with machinery, and, in an effort to improve the livestock of its members, has been the first to adopt a pedigree bull scheme.

There are, too, the *Mutual Aid Groups* of the Worthing and West Sussex area. These were formed originally in August 1942 for the pooling of machinery and labour. But they have since developed into discussion groups, and much more emphasis is now laid on meetings, lectures and discussions, and less on the lending of implements. There are now over 40 groups working with greater or less success. At the start West Sussex was divided into a number of relatively small areas, in each of which a Mutual Aid Group was formed. Every grower, large or small, within the area was invited to become a member of the Group and to attend meetings for the purpose of discussing every kind of problem affecting members. A Chairman was elected by each Group, and the Chairmen constituted a Group Council responsible for the whole of West Sussex. Meetings are held regularly, visits to other districts are arranged, all manner of topics are discussed, propositions are debated and sent up to the Group Council. Problems of cultivation, diseases, pests, supplies, transport, etc., are constantly under review and growers within any one Group assist one another in many practical ways.

(3). *Other Rural Institutions of Self-help and Self-education in Great Britain.*

The following additional organizations must be briefly mentioned in order that they may not be forgotten in the suggested re-organization of Rural Adult Education.

(*a*) Closest to the 'Farming Clubs' are the '*Young Farmers Clubs*,' a movement brought into being in 1921, and with a present (1945) membership of over 56,000.

(*b*) Corresponding in their aims with the 'Farming Clubs' in their own sphere of rural domestic economy are the *Women's Institutes*. The first Institute was formed in Wales in 1915. In 1939 there were 5,740 Institutes with 328,000 members.

(*c*) The *Workers' Educational Association* was founded in 1902. Though the work of the W.E.A. has steadily expanded, the 1936 report still spoke of "the Hinterland of rural areas waiting to be served."

(*d*) An interesting development is the organization of '*Blacksmiths' Discussion Groups*' sponsored by the Yorkshire Rural Community Council. Similar Discussion Groups are now being organized for wheelwrights and joiners.

4. One important experiment concerned with rural adult education must be recorded in this connection, *viz.*, the Avoncroft Residential College for rural workers. This Institution is run on the lines of Danish Folk High Schools with a largely cultural curriculum including history and English as well as agriculture and economics.

II. Similar movements in the United States.

The idea of self-education has aroused great popular enthusiasm in the United States and no group was more receptive to the idea of self-improvement than the farm people. Space allows us to deal only with the most recent of these movements, *viz.*, the *Farm Bureaux.*

The Farm Bureau is a type of farmers' organization which differs in many respects from all others. It was created as a deliberate, constructive movement to promote agriculture, home and rural life, to make farming an efficient and profitable business, rural home life fuller and richer and to improve the community life of the country as a whole.

The Farm Bureaux developed out of an organised effort on the part of farmers to support the work of extension agents. The Bureaux were to provide a nucleus of farm leaders to assist the county agent (the American equivalent to the English County Organizer) to carry out extension projects, and to aid in financing the work.

The extension movement itself was designed to carry the accumulated knowledge of the scientific institutions (agricultural colleges and research stations) to the individual farmer. The idea of county agents, or 'agricultural experts' took root just before the first World War. Originally financed by commercial companies and organizations for the purpose of increasing farm production and so creating a better farm market for city goods, the scheme was later taken over by the U.S. Department of Agriculture and developed into the present system of agricultural extension, financed jointly by State and Federal funds. The work was supported from the outset by a few county Farm Bureaux, composed chiefly of farmers interested in improving their farm practices, who welcomed the help of a scientifically trained man in their respective counties.

The county organizations of farmers supporting the work of extension agents developed under different names and only gradually adopted the term 'farm bureau'. But in 1916 the name 'County Farm Bureau' was adopted by a number. In 1917 began a definite movement to standardize functions, based on the conception of a Farm Bureau as a quasi-public body, constituting a part of the extension organization and formed for the specific purpose of assisting in developing a county programme of extension work. In twelve States it has been enacted that the co-operating group shall be the Farm Bureau. In the rest of the country co-operating groups vary in constitution but typically include outstanding farmers and representatives of governmental bodies, schools and farm organizations.

As the number of farm bureaux and county agents increased the movement for the formation of *State Federations* of county farm bureaux developed.

By the time the State Farm Bureau Federations were well organized and in active operation, there was sufficient sentiment in favour of a *National Federation* to warrant a definite movement in that direction. In 1919 a temporary organization and constitution of the "American Farm Bureau Federation" was adopted and this was made permanent in 1920. This was :—

> to correlate and strengthen the state farm bureaux and similar state organizations of the several states in the national federation; to promote, protect and represent the business, economic, social and educational interests of the farmers of the nation and to develop agriculture.

The strength of the County, State and National farm bureau organizations is dependent upon county leadership.

It is especially interesting for our purpose to note how the relations of the Farm Bureaux to the Extension Service have been defined in the resolutions of 1939.

> Farm Bureau-Extension relationships. In a large number of states, county Farm Bureaux have been established by law or by mutual agreement as the official local unit of the co-operative Extension Service in agriculture and home economics. In many others, although not so designated, the county Farm Bureaux work in close co-operation with the county farm agents, home demonstration agents and 4-H Club agents. The County Farm Bureau movement was organized for this and other service to farmers. This friendly working relationship should be maintained and strengthened in these States and extended to such other States in which it is possible for the Farm Bureau to co-operate with the Extension Service in developing and carrying out agricultural programmes. We will resist all efforts to destroy or impair this fundamental teamwork of education and organization which has meant so much to the welfare of farm people throughout the years.

In the event, however, co-operation between the Extension service and the Bureau became increasingly difficult as the National Federation became increasingly involved in political action.

The tasks of the Agricultural Extension Service are :—

(*a*) Assisting rural people to discover and analyse their problems ;

(*b*) Developing leadership among rural people that will enable them to organize themselves into effective groups to meet their problems ;

(*c*) Disseminating information that has been learned by practical farm and home experience and by experimentation and research to rural families in such a way that the information will be used ;

(*d*) Acquainting the land-grant colleges and the U.S. Department of Agriculture with the problems of agriculture that need research.

In view of the nature of the Extension Service programme and the close relationship which ordinarily exists between extension agents and the people in their area, a great deal of Extension Service work is conducted through personal contact. But extension workers are increasingly attempting to deal with organized groups, so that information can be conveyed to a number of persons at one time.

If extension workers were to attempt to meet regularly with such organized groups, it would leave them with little or no time for their other duties. To meet this situation, very early in the history of the Extension Service, extension agents began to enlist the help of well-equipped local people in their work with both children and adults. To provide leadership for the expanding demonstration programme, for example, outstanding farmers were given special training so that they could demonstrate scientific agricultural practices to their friends and neighbours. Local leaders are the Extension Service's most effective arm in reaching rural people.

The use of local leaders—now called "neighbourhood leaders"—has more than fulfilled its original purpose of aiding the diffusion of scientific knowledge about farming and home-making. The close contact of leaders and extension workers has helped to keep the extension programme attuned to the wishes and needs of farm people. Participation in leadership work has been of great value to the leaders themselves. Many men and women have acquired an authoritative knowledge of particular phases of farming or home-making as a result of the years of training they have received. In the process of learning and teaching their neighbours they have acquired increased self-confidence and have developed latent abilities. It has been said that "it appears that the extension agents will best serve their country if they will eliminate most of the general direct teaching methods and personal services, and devote their time, energy and ingenuity to perfecting the organization of all rural people to the end that they can be taught by *local voluntary leaders.*"

The existence of the network of competent and reliable local leadership throughout rural America is actually and potentially of great value to the nation, since,

(*a*) the local leadership discovered and developed will remain as a socially valuable resource in the rural communities

(*b*) the systematic organization of neighbourhoods and communities holds possibilities for a new community integration which has significance for the economic, social, cultural and institutional life of the rural communities.

The Extension Service makes good use of almost every important method employed in adult education. Since its beginning the Extension Service has disseminated information through demonstrations, the written word (bulletins and pamphlets), by broadcasts, films and exhibits. Demonstrations have been one of the most successful and characteristic means of securing widespread and rapid acceptance of recommended practices, because they furnish convincing proof of the value of modern practices on the farm and in the home. Their value is heightened when they are conducted by farmers of farmers' wives.

Furthermore, in most States the Extension Service sponsors "Farmers' Institutes" or "Farmers' Weeks" in the various counties, during which those in attendance consider

co-operative approaches to their common problems. These institutes are schools, lasting a few days, on such subjects as farm machinery, beef-cattle feeding, gardening, dairying, soils and crops. A number of land-grant colleges offer short courses for farm people. A traditional annual feature at every state agricultural college is "Farmers' and Homemakers' Week," including speeches of general interest and opportunities for intensive study in a wide variety of aspects of farming and rural domestic economy.

Discussion Groups. In addition to disseminating information, the Extension Service has encouraged rural people to think out their own social and economic problems by promoting the organization of discussion groups. Realising the need for encouraging such thinking, the Bureau of Agricultural Economics of the U.S. Department of Agriculture adopted in 1935 a plan for developing study and discussion groups among farm men and women, boys and girls. After various changes this project is now sponsored by a special agency, the Division of Program Study and Discussion.

These discussion groups were initiated as a rural adult-education movement to give the farmers the necessary 'factual data,' to enable them to make intelligent decisions concerning agricultural policy and to assume an active part in directing it. The discussion movement was to act as an important basis for the concept of 'economic democracy,' *i.e.*, to encourage farmers to participate intelligently in policy forming and in the administrative phases of agricultural policy.

The movement is based on the widest discussion of some of the great public issues, for example :—Can government interfere with economic trends ? What adjustments do we need to make in our society to bring about a better rural life ? These are profound questions and they cannot be answered by the agricultural scientist or specialist. But the farmer wants such questions answered, or at least he wants to talk them over and find out what others think about them.

But it was felt that the study and discussion of these wider problems required educational help. The desire and drive were there, but assistance was needed in getting things started, in learning the few simple things that enable a conference or a discussion group to take best advantage of the time at its disposal, and in getting accustomed to listen to other views without impatience, intolerance or anger. Farm people need to be shown that the way towards profitable discussion is simple. State extension directors have been encouraged to appoint a state discussion group leader, and in 37 states they have done so. These men work in co-operation with the regional experts in the Division of Program Study and Discussion, organizing meetings throughout the State for periods of a week or two, to train discussion leaders among farm people. At these meetings demonstration discussions are presented to farm men and women interested in organizing a group in their local community ; organization technique and methods are discussed, and the demonstration is criticised.

The great difficulty with this method of education is that it does not go far enough to enable people to satisfy themselves regarding the questions they ask. To overcome this, the Division has issued some half-dozen " method pamphlets " telling how to organize and conduct a discussion group, and also about 20 subject-matter pamphlets. Over two million copies of these pamphlets have been distributed by the Department to the State extension leaders, who send them to groups of local farmers through the county agents. The discussion pamphlets are frankly controversial, presenting contrary points of view in conversational form, and they include bibliographies of other free or cheap pamphlets on the same subject.

'*Schools of Philosophy.*' Growing out of this discussion-group programme there developed a more formal project designed for the farm leaders of a State, who would assemble for a period of several days to discuss the broader phases of the agricultural programme.

The earlier meetings were attended by extension workers only—county agents, home demonstration agents, 4-H Club leaders, extension specialists. These meetings soon became popularly known as 'schools of philosophy.'

So well did these schools meet the need of the field workers that they were later extended to include farm leaders, especially committee-men, and the other staff members of the Department and of the colleges of agriculture; they are now also being held for teachers in vocational agricultural schools and the professional and business men of towns in rural areas. The schools provide an opportunity for participating in discussion groups, and thus fit in closely with the more direct demonstration and leadership-training conferences held to prepare farm people to organize and conduct discussion groups in their homes.

The character of the schools differs with place and time. But all have worked towards a better understanding of the relationship between intimate local problems of a comparatively small community and those of national and international scope.

III. Farm Experimental Work in Germany.

With regard to education by experimental work, an interesting development took place in Germany which is worth recording in this connection. An account of this work has been given by W. Morley Davies :—

> In 1923 Roemer of Halle assisted in forming the first Experimental Group or 'Versuchsring' (Experiment Association) as it was (and is) called. A "Versuchsring" consists of a group of farmers all living in one district. The leader is a farmer, preferably one who holds an agricultural diploma. A levy is made on the total acreage represented by each farmer in the ring. From this levy the salary and expenses of a supervising assistant are paid. . . These rings were at first purely private enterprises. But then the Government gave an annual grant to each group through the Chambers of Agriculture.
>
> In the main the experiments were crop variety trials to find out the suitability of crops and seeds for the different districts.

Part 'B'—The 'Farming Clubs' of the Future.

1. The Sociological Foundation.

Because of the rapid progress of mechanization and the advances arising from scientific discovery, a vast amount of essential knowledge affecting agriculture has accumulated. Thus farming now requires more technical knowledge and skill than ever before. Re-adjustments in farming techniques, however, represent perhaps only the simplest changes necessitated by technological and scientific developments. Years of depressed prices have taught the farmer that his problems are not local in character. Agriculture has become a part of a complex and unstable industrial economy and the repercussions of this development have been felt in every phase of rural life. Farming has become a complicated business influenced by business cycles and by national and international developments.

To-day both successful farming and the fulfilment of civic responsibilities demand a broad range of knowledge in many fields. George Bernard Shaw expressed this admirably :

> "We expect each farmer to be able, single-handed, not only to plough and hoe, to reap and sow, but to be an agricultural chemist, a veterinary biologist, an accountant dealing with complicated costings, a statistician, a man of business skilled in buying materials and selling products, an up-to-date reader of Lord Bledisloe and the scientific investigators and an expert in half-a-dozen other capacities utterly foreign to his antecedents."

In addition, farmers require increased social understanding, changed attitudes to, and new techniques of co-operation, for many of the problems faced by rural people can be solved only through common effort.

Hence, the three-fold ideal expressed by Sir Horace Plunkett—" Better farming, better business, better living "—still stands : " better farming " : through full knowledge of the facts given to us by technological and scientific developments ; " better business ": through the full understanding of the economic processes involved ; " better living " : through the recognition of man as a social being.

This aim can be achieved fully only by adult education.

This point of view is fully recognized in the White Paper on Educational Reconstruction, para. 85 :

> " Without provision for adult education the national system must be incomplete, and it has been well said that the measure of the effectiveness of earlier education is the extent to which, in some form or other, it is continued voluntarily in later life. It is only when the pupil or student reaches maturer years that he will have served an apprenticeship in the affairs of life sufficient to enable him fully to fit himself for service to the community. It is thus within the wider sphere of adult education that an ultimate training in democratic citizenship must be sought."

Adult education is essential to the successful functioning of a democratic system in a complex and rapidly changing world. Once this fact is recognized, limitations of resources will be the only important obstacle to the rapid development of a programme which attempts to meet all the educational needs of the rural adult population. Adults—men and women—need adequate educational opportunities to secure the benefit of new scientific discoveries and to equip themselves to deal with the problems set by economic and social changes.

The basic principles of adult education are voluntary attendance, freedom of enquiry and free discussion. Adults must be free to study subjects of their own choice. Furthermore properly conceived adult education, by emphasising freedom of speech and fair hearing for minority views, forms the basis of good citizenship as understood in a democracy.

We saw above that the aims of adult education fall into two distinct categories—to make the members of the rural population (*a*) efficient in their calling and (*b*) good citizens. Hence the content of adult education has also to be twofold : ' vocational ' or ' technical ' and ' liberal.' ' Technical ' education aims at preparing a man to earn a living or to make money, or else at training in some particular technical skill, whereas " liberal " education aims at producing as perfect and complete a human being as may be.

Liberal education comprises a vast variety of subjects but can, according to Sir Richard Livingstone, be broadly defined under two heads—the study of the material universe, and the study of man as a sentient, thinking and spiritual being. This kind of education has sometimes been considered useless for the rural population, but it should not be forgotten, as has been so aptly said, that " The continued discussion of how to raise crops can become stale."

Moreover we can see from reports on the Danish Folk High Schools how this liberal education has helped to produce better farming. The underlying reason for this perhaps surprising result is simple. The threefold aims of " better farming, better business, better living " are intrinsically so inter-connected that, in our modern world, no one can be achieved without serious effort to reach the other two. This fact has been clearly recognized in the United States by the establishment of Discussion Groups and of the ' Schools of Philosophy.'

It might be argued that while these ideas and aims may be sound and worth achieving, the rural population has no interest in its own education for wider knowledge and understanding. That such a view is not in accordance with the facts is, in the writer's opinion, proved conclusively by the splendid development of rural institutions for self-education especially during the last few years. There is at present a widespread and profound desire for wider knowledge of facts, and for the better understanding of their underlying causes,

a thirst to know both ' how ' and ' why.' In an earlier part of this paper we have dealt with the main institutions and agencies promoting adult education in rural areas. Judged by results their endeavours suffer from lack of balance and co-ordination. Their main weakness is that the education which they give is for the most part casual and scrappy—stray lectures or courses of lectures, haphazard discussions and demonstrations, overlapping activities, " stimulus rather than education, a cocktail rather than solid food."

To achieve the real objective something more systematic and methodical is needed. The time therefore seems ripe for putting rural adult education into a sound, balanced and co-ordinated frame-work. No one would wish to undo what has been achieved ; our aim should be to stimulate the growth of the institutions that are already in being, and to mould them to an integrated whole. The promoters of such a plan must be the voluntary bodies already engaged in this work.

But the end envisaged—a balanced, co-ordinated and integrated organization of adult education in rural areas—can be fully achieved only if one of the voluntary bodies is made the leading partner, around which the others can be logically grouped. In the writer's view the leading role can and should be played by the existing ' Farming Clubs ' modified where necessary and working together in a national organization.

There are various reasons why we choose the ' Farming Clubs.' Firstly, all other voluntary bodies have become connected in the minds of the people with one or the other particular activity, and are so fixed in their present settings that it would be difficult to develop them in the desired direction. But the ' Farming Clubs ' are young, have not yet found their final form and thus could be moulded easily for the purpose in mind. Secondly, other institutions cater only for particular groups of the rural population, whereas the ' Farming Clubs ' as we shall see later, could be so developed as to provide the great majority.

It might be objected that there is already in being an organization, the National Farmers' Union, which could fulfil all the needs of the rural population, but there are three reasons against the adoption of the N.F.U. as the leading partner in the proposed framework. Firstly, the N.F.U. comprises only one group of the rural population, *viz.*, the farmers ; secondly, how far has the N.F.U. hitherto worked towards the broad aim that we envisaged—" Better farming, better business, better living "? Last, but not least, the N.F.U. is essentially a " Trade Union." Its main purpose, despite its recent efforts to widen its activities, is to look after the business interests of the farmers, as individuals and collectively. As shown in its motto : " Defence not Defiance " its main object is to secure the *economic* well-being of the farming community. The organization we need is not one aiming at economic protection but at promoting the well-being of the rural population in *all* respects.

For similar reasons the Agricultural Workers' organizations are unsuited to play a vital part in the organization of rural adult education. Their main function is the defence of the economic position of the farm worker..

For all these reasons it is here proposed to make the ' Farming Clubs ' the central institutions for the promotion of adult education in rural areas. So far the argument has been that no other existing institution can undertake the task ; in the following pages it will be our endeavour to show how the Clubs could be made to fill the need.

II. Practical methods to be Adopted by the ' Farming Clubs.'

1. *Vocational Education.* The aim of the F.C.'s should be, in conjunction with the appropriate statutory bodies which we shall discuss later, " to translate the knowledge of the few into the practice of the many."

A few essential facts must be borne in mind in relation to this aim. Adults, on the whole, learn a little more slowly than young people ; they have less acute vision and hearing, a slower reaction time and greater fear of failure. Therefore, the teacher must concentrate

on one thing at a time and develop it in logical sequence, first the ' why,' then the ' what,' the ' how ' and the ' when.' For these reasons it is important to give each member of the audience something on paper to take home.

It is desirable that each Club should circulate a monthly News-Letter to its members, giving the essence of the talk, lecture, discussion, etc., heard by the members during the previous month. Moreover, these News-Letters should indicate sources of further information on the matters discussed. There is a further point of importance ; as Sir Richard Livingstone has said in regard to the schools : " If the school is unable to teach people to *wish* to read for themselves, it will be unable to teach them anything else of value."

The Clubs in order to achieve their aim must adopt all the methods which have proved effective in other educational institutions, whether at home or abroad.

Talks by practical farmers and lectures by technical officers and scientists should be the basis of the normal winter activities of the clubs. Concerning these, it will be necessary firstly to develop the stray lectures into an orderly course based on an underlying general idea, *i.e.*, a course of lectures on one subject only or on subjects which follow each other in a logical way. But, in order to avoid the atmosphere of the schoolroom, it would be best, it seems, to have two sets of meetings : one providing a course of lectures and the other talks and discussions based on subjects of topical interest, and to alternate these. It might even be necessary for larger clubs to form separate study groups so as to avoid overcrowding the regular courses. The largest number for such a study group to be fully successful should be between 20 and 30.

All this implies that the Club programmes should be considered and planned to cover more than a single session. Furthermore, these programmes would have to be co-ordinated and integrated with the programmes of the other institutions working in the same district.

The high value of ' free for all ' discussions in all Adult Education programmes is now widely recognized. All talks and lectures should be followed by a discussion, and the time devoted to this should be at least equal to the length of the talk or lecture. But there should also be, from time to time, meetings entirely devoted to discussion between the members themselves. The object of these should be the exchange of experience of new ideas and techniques, and accounts of their application. Troubles should be reported and remedies discussed. But discussion must not become an end in itself. It should lead to wider reading, to more formal study and to *action* based on the new knowledge thus acquired. It seems that in some counties too much emphasis has been placed on discussion in the sense that it is considered as the essence of Agricultural Adult Education and not as only one of the means to the end. " We should be careful not to suppose that these war-time improvisations have made the older emphasis on knowledge, continuous study and good teaching out of date."

It must be kept in mind that the aim of ' vocational ' education is ' to enable us to earn our bread.' Thus the many varied scientific foundations of agricultural knowledge and practice must continue to provide the main content of talks, lectures and discussions.

To underline the theoretical work it is necessary that *ad hoc* demonstrations should be organized, mainly during the summer months, to show the practical applications of the knowledge gained. Furthermore, standing demonstrational plots should be laid out at convenient distances from the club areas. This work has been very successfully started by most County War Agricultural Executive Committees, and should be continued to an even larger extent.

To make the practical man acquainted with the work of the scientist and to establish a valuable personal contact between these two groups, summer programmes should include visits to Experimental Stations. Such visits are the more fruitful and effective because they show the practical man that the scientists are working for his benefit. Most people,

had they such opportunities, would lose the notion that the scientist is working in an atmosphere of seclusion and away from the problems of everyday life.

The demonstrations and visits advocated in the preceding paragraph should induce the club members to experiment for themselves, and so benefit the whole neighbourhood. What is here envisaged is something on the lines of the " experimental rings " as developed in Germany. Such work could easily be fitted into the general framework of the clubs.

Finally, all this work should be rounded off by the collection of crop reports, to give the individual farmer insight into the prevailing local conditions, and so help him in regard to the marketing of his produce.

2. *Liberal Education.* The aim of the 'liberal' education, as provided by the Clubs, should be the advancement of the rural community, intellectually, socially and economically. Especially it should include education in citizenship ; a training for the exercise of the vote, based on sound reasoning. To avoid unnecessary repetition we refer back to what was said above on the activities of the American Discussion Groups and in particular the 'Schools of Philosophy'.

There should also be education in co-operation, which is only another aspect of good citizenship. This has been recognized by the Pools and Mutual Aid Groups described above. Moreover, the necessity of starting co-operative associations in an organized way is more and more recognized by practical men as well as by theoretical economists.

The European Conference on Rural Life expressed its opinion on the educative value of co-operative organization as follows :—

> " To view co-operative action solely from its economic side and to ignore completely its educational, moral and social aspects would be to obtain an incomplete and misleading impression of it.
>
> The whole history of the co-operative movement—in the cities as well as in the villages—shows that there is a sort of natural affinity between the needs which give birth to co-operative action and the need for education ; indeed, both are linked up with a belief in progress—a progress by self-help. This means not only that the decision to establish a co-operative organization, or adhere to one, and the resulting collaboration in its management, presupposes some knowledge and a certain intellectual and moral standard ; it means also that, directly or indirectly, co-operative work contributes most effectively to the economic education of the producer and consumer and to the development of their personal qualities."

The same observations as to the educational value of co-operative organizations have been made in the United States.

But before a farmer can advance a reasoned opinion on practical or co-operative action, he has first to receive instruction on general economic and social subjects. For a full understanding of these subjects the club members would also have to learn something about rural history and geography.

The methods to be adopted for 'liberal' education should be the same as for 'vocational' *i.e.*, talks, lectures and discussions.

3. *Connected Services.*

(*a*) Libraries and " bookmobiles." It has been rightly said that one of the main endeavours of education must be to influence people to read. Hence, a well-organized library service should be established in all rural areas. It is important to make the greatest possible use of travelling libraries. Transport facilities enable the rural library to extend its service to a far greater number of individual readers ; they bring to the people the services of a librarian, for a trained person should either drive the library van or accompany the driver. The librarian is the pivot upon which the success or failure of a village library

depends. He or she must study the needs of his or her clients, and, if possible, extend their numbers.

The experience in the U.S.A. with "bookmobiles" has shown that many rural people await the arrival of the librarian to ask him what to read in connection with some particular interest, and that they regard their contact with a librarian who is interested in their problems as the most beneficial aspect of library service.

Furthermore, there should be, for the members' use, at each of the local Farming Club Centres, a reference library of standard textbooks on technical and practical farming and related subjects as well as agricultural journals.

(*b*) *Text Books and Agricultural Journals.* A library service as outlined above can be successful only if it is provided with material to serve as a source of sound and comprehensive information. The main need here is for suitable text-books. These would have to be specially written in order to fulfil the requirements of an adult group intent on gaining the necessary knowledge and to supplement the talks, lectures and discussions.

The task of agricultural journals should be the dissemination of information on (*a*) practical farming operations and all subjects connected with these, including engineering; (*b*) new developments in practice and theory, including the results of experimental work; and (*c*) on the activities of all bodies and agencies connected with the industry. Furthermore, the Journals should contain lists of books where comprehensive information could be found on the subject dealt with.

(*c*) *Visual Aids.* There is at present a great deficiency in all visual-aid equipment. Farming Clubs should have at their disposal not only projection equipment for films and slides, but also an adequate stock of suitable maps, wall charts and diagrams covering all the subjects of their activities. The setting up of Visual Education Centres for the different regions, as has been done in the South-West, is highly desirable.

(*d*) *Wireless.* The service of the wireless in disseminating information is of great importance, as has been shown during recent years. This service should be extended on the same lines as outlined for the Journals. Reports on market conditions at home and abroad should be included in the service, as is so successfully done in the United States.

III. The proposed organization of the 'Farming Clubs.'

1. *Membership.* The essential idea of the suggested Clubs is that their membership must include *all* farm people, male and female, masters and men. Every effort should be made to include the employee and to interest him in the club work. The quality of his work will improve with every step in the direction of knowing the "how" and, not least, the "why." He will then work not solely to earn his living but also because he has the interest that comes from understanding. If the farm worker is to take his rightful place in the community, it will be necessary to give him the same facilities for learning and understanding as the master. After having received such an education farm workers will have the same standing as members of other trades, so that there will be no reason why they should feel themselves inferior. Furthermore, the union of masters and men in the clubs will foster the team spirit which is perhaps even more necessary on the farm than in other employment. But again, membership should not be confined to farm people. It is of the utmost importance that farmer and worker should be brought into close contact with the members of ancillary trades. If the rural community wants to be considered as an entity, all engaged in rural crafts and trades should have a common meeting-ground. Each should know the other's problems. Modern developments in technique and in social and economic conditions have brought about such a close relationship between the different crafts and trades concerned with agriculture, that it is necessary that all should act as a group.

Comprehensive membership would, above all, make the clubs the chief means of rural adult education.

2. *Club Leaders and Organizers.* The officers of the clubs should be unpaid and should be elected by the members from among themselves. Care should be taken to guarantee fair representation, on the club committees, of all groups. To ensure that the work will not be confined to one or two leading members of the clubs, there should be a number of Sub-Committees, *viz.*:—

(*a*) A Programme Sub-Committee to plan the whole programme and arrange for speakers.

(*b*) A Competitions Sub-Committee to arrange competitions in the club area in the various agricultural crafts—thatching, hedging, ploughing, etc.

(*c*) An Experimental Sub-Committee to arrange small variety trials, manurial trials, feeding trials, etc.

(*d*) An Entertainment and Social Sub-Committee.

But the whole success of a club depends on finding the right persons to act as club leaders. Club leaders must have drive, vision and knowledge. They must know all the sources of information and the whole apparatus of the agricultural organization and its personnel, and, last but not least, they must be able to act as discussion leaders.

The first step in the practical development of the proposed scheme must, therefore, be the training of suitable persons as club leaders. A plan would have to be developed for such training. Club-Leader Schools should be held at Agricultural Colleges or Institutes and should provide comprehensive courses of instruction, once a year and lasting perhaps a fortnight. The importance of this whole question has been well recognized in the United States, where a definite voluntary leadership plan is in operation.

> " Our progress in agriculture will be limited and very slow without farm leaders and we cannot develop these leaders without the voluntary leadership plan. . . .
>
> The job of perfecting the community organization can best be accomplished by training the project and neighbourhood leaders with the help of college specialists. . . . .
>
> Leaders ought to be made to feel that they are leaders. About once a month a letter should be mailed to voluntary leaders only. Once or twice a year they should receive a personal visit from the county agent. These leaders also deserve to have a report from time to time showing the accomplishments of their communities and counties.

We suggest that a similar plan for training local leaders should be adopted in this country. Furthermore, it would be necessary, especially at the beginning, to employ full-time Club organizers. There should be at least one such organizer in each county. The organizer should be attached to the staff of the County Organizer and should be in touch with all the agencies concerned with rural education.

The organizer should be responsible for the forming of new clubs, so distributed as to ensure that the whole of his county is covered. He would give necessary assistance to the local club-leaders, in the general running of the clubs, in the drafting of programmes, in the finding of suitable persons to give talks and lectures, in the provision of printed information material, etc.

To ensure the smooth running of the whole administration and organization of the scheme it will be necessary to bring all who occupy leading positions in the movement into close personal contact. The system as proposed by Prof. Ashby for the Young Farmers' Clubs movement should with appropriate alterations be adopted for the adult organization.

Besides the suggested system of common instruction for Club Leaders, Organizers, etc., it might be very useful to develop a special organization for Club Leaders. The leaders in any one county should be brought together into some form of a common council. This common council of all the Club Leaders in any one county should then constitute a County

Planning Committee. Again, all Club Leaders in Great Britain should form and be members of a special National Association. This Association should disseminate information and should hold annual meetings at which the problems affecting all leaders could be discussed. Finally, this Association should ultimately establish a residential college for Club Leaders somewhat on the lines of the Scandinavian Folk High Schools.

3. *Area Organization.* The smallest unit should be the *local* club catering for five to eight parishes according to the local conditions. From the local clubs elected representatives should attend group meetings in order to bring and keep the clubs of the neighbourhood in close contact, to arrange combined visits, demonstrations, experiments, social gatherings, etc. Alternatively the chairmen of the local clubs could constitute a Group Council like that which is a part of the organization of the Mutual Aid Groups.

Elected representatives of local clubs should attend regular county meetings to co-ordinate the work in their particular counties. These county meetings should be made statutory and should be attended by the members of the county planning committee, *i.e.*, by all the local club leaders. There should be a proper county branch with its seat in the county town. A full-time secretary in charge of the county branch should act at the same time as secretary to the county planning committee. Sub-committees should be constituted according to the work to be performed in the different branches of farming, *i.e.*, dairying, livestock, horticulture, etc.

The county should be made the key administrative unit when dealing with the relations of the clubs to the Local Education Authority and the County Agricultural Adviser. The regional or provincial organization should coincide with the proposed provinces of the National Agricultural Advisory Service. Members to attend provincial meetings should be elected from their own numbers by the members of the county branch. Here also sub-committees should be brought into being.

Finally, there should be a National Federation of all the clubs in Great Britain. A member of each club should represent his own local club at the annual meeting of the National Federation, and should report back the transactions of this meeting to his fellow members.

4. *Name.* The name of the clubs should express the idea that the clubs are the common meeting-ground of all people living in rural areas and are connected in one way or another with the farming industry. The name should also bear close reference to the locality which the local club or the higher group is serving. "The. . . .Farm Community" is tentatively suggested. A local club would then, for instance, call itself: "The Windsor Farm Community," a county branch: "The Oxfordshire Farm Community," the provincial unit: "The South-West Farm Community"; and the national federation: "The National Federation of Farm Communities."

5. *Meeting Places.* The obvious meeting-place for the local "Farm Community" is the Village Hall, serving as it does as the general social centre and the focal point for all village activities. The Ministry of Education Report on "Community Centres" demands that "Provision for a Village Hall should be made in all villages with a population exceeding 400."

Besides the common hall for meetings the Village Hall should include a Club Room which might be shared by the different institutions active in the village. The Club Room should contain the Reference Library of the local unit, ready to be consulted by the members at any time.

District. The ideal meeting ground for the meetings of the proposed area, group or district unit of the 'Farm Community' would be the 'Village or County Colleges' to be established on the lines of the Cambridgeshire Village Colleges.

At these colleges opportunities should be provided for training rural craftsmen. There

should be a classroom specially designed for this purpose and fully equipped with the necessary machines and tools for training blacksmiths, carpenters, etc., on the lines of the scheme prepared by the Herefordshire Rural Industries Council.

But, in our opinion, these 'Village Colleges' should be used, as far as adults are concerned, only for purposes and requirements *common* to the "*district*," *i.e.*, to a relatively large number of neighbouring villages. Activities at the 'Colleges' should be restricted to matters concerning the whole area and to activities which could not well be undertaken by the local unit—such as the training of blacksmiths—in order to avoid the draining of activities from single villages. Activities at these colleges must not interfere with the healthy local activities of the local unit at the Village Hall.

County. There should be a building in every county town specifically designed to house all activities concerning the farm community at the county level. We incorporate here a proposal made in the United States and suggest that it might be adopted in Great Britain :

> "a building which would adequately house all activities of the U.S. Department of Agriculture at the county level and provide adequate facilities for local farmers and their families would do more than any other one thing to consolidate the efforts of the Department in a unified working program. It would provide the farmer with a centre for information and service that would mean greatly increased participation in all agricultural programs."

Such a building should provide accommodation for the County Organizer and his staff, for other Ministry of Agriculture officials, and for various voluntary organizations concerned with rural education and recreation. There should be a lecture hall and a library. A step in this direction has already been taken by the Cambridgeshire Rural Community Council in getting a home for voluntary organizations, namely ; Cambridgeshire House.

Region : The meeting-place and office of the provincial unit of the 'Farm Community' should be in the same building as the headquarters of the Provincial Advisory Service. Professor Rae has suggested :

> "in our post-war planning we might with profit give very careful consideration to this question of provincial boundaries and the location of the various provincial headquarters at one centre. It does allow at least frequent and easy intercourse and meetings between teaching, research, advisory and administrative staffs."

Thus, a provincial centre would be the ideal place to house *all* activities concerned with the province.

National : The National Federation of Farm Communities should have its headquarters in an adequate building in London.

IV. Relations of the "Farm Communities" to other Bodies.

1. *The Local Education Authority and the National Advisory Service.* Under Clause 1 of the Education Act 1944, the duty is laid upon the Minister in charge of education to promote the education of the *people* of England and Wales, *i.e.*, not merely of children and adolescents, but of 'the people,' and to promote the progressive development of institutions devoted to that purpose. With regard to this Clause Mr. Butler remarked that the Minister could assist new forms of organization to further the educational effort.

On the other hand the duty of providing technical advice to adults engaged in agriculture is to be transferred from Local Authorities to the Ministry of Agriculture and a National Advisory Service is to be set up. It is clear that the County Officer of the National Advisory Service will have to collaborate with the Local Authority in providing the assistance that the Clubs will require.

2. *Universities.* Besides the L.E.A.'s and the National Advisory Service there is a third independent body, namely, the Universities to which the Farming Communities may look. The connection between the Universities and the organization of the "Farm Communities" will have to be established at the provincial level. The Universities will be able to supply lecturers in their respective provinces, by request, down to the local level.

3. *Young Farmers' Clubs.* The Y.F.C.'s should be the main feeder organization of the local "Farm Communities" with regard to the ordinary membership and especially to the leadership group. Members of the Y.F.C.'s are being trained in all the necessary knowledge and techniques to enable them to become Club and Discussion Leaders. Thus, there should be a close co-operation between the Y.F.C.'s and the "Farm Communities." Where there are already Y.F.C.'s in existence they could help in establishing Farm Communities" by calling on the assistance of former members of the Y.F.C.'s who have resigned owing to reaching the age limit. On the other hand, where to-day "Farming Clubs" are in being, they should stimulate the foundation of Young Farmers' Clubs in their areas. Such collaboration would ensure to the full the continuity of both teaching and programmes, and thus the fullest possible development of their members.

4. *Women's Institutes.* The Women's Institutes should be the sister organization of the 'Farm Communities.' The instruction in agriculture and homemaking has to be correlated at the adult, as at the youth and high-school levels. This has been successfully carried out in the United States by the Extension Service, which is concerned with agriculture *and* homemaking (or home-economics) as the two main material bases of rural life.

There is now a widespread feeling in the W.I.'s that such a correlation is necessary and this feeling is shared in many other quarters. This idea can be put into practice immediately "Farm Communities" are established all over the country. There should be a liaison officer of the W.I. at the "Farm Communities" and *vice versa*, to ensure the planning of community programmes in agriculture and homemaking. Besides these 'vocational' educational activities, meetings of either body devoted to 'liberal' education should be thrown open to members of the other.

5. *Workers Education Association.* The W.E.A. should provide for *courses* planned to supplement the 'liberal' education of the "Farm Communities", and the Women's Institutes.

6. *Common Councils.* (*a*) *Adult Education Councils.* To safeguard at the local level a co-ordinated and integrated programme for all the agencies concerned with rural adult education it is suggested that an 'Adult Education Committee' should be established in each village. This should consist of representatives of all the statutory and voluntary bodies in each village concerned with education.

But the ideal to be achieved would be, in our opinion, the forming of a "Village Community Council" or a "Community Association" of men and women representing every organization, every interest and every class in the village. Thus a fully organized community life could be brought about, avoiding overlapping or gaps in the different activities and preventing misunderstanding and illfeeling. Such a council would be responsible for all activities, including education in economic and social matters.

(*b*) *County Rural Community Councils.* What was said with regard to the necessity of co-ordination of activities and programmes on the local level applies with equal force to the County level. There is already in existence the successful organization of Rural Community Councils in twenty-two counties in England and Wales. Thus the need only arises to form in all counties such a R.C.C. The County Organizer and the representatives of the "County Farm Community" and of the "County Planning Committee" should be members of the R.C.C.'s along with the representatives of all the other statutory and voluntary bodies. As the R.C.C.'s have their national parent-organization already in the

National Council for Social Service it must be considered whether it would be of value to establish also a provincial federation to enable this co-ordinating agency to do its useful work on this level as well.

V. Relation to farm-business and industrial organizations.

1. *The National Farmers' Union and the National Union of Agricultural Workers.* We explained above that in our opinion the N.F.U. is essentially a " Trade Union " for the farmer. Thus the relationship between the ' Farm Communities ' and the N.F.U. should be fixed so that the N.F.U. would act as the political and business executive of the farmer members of the " F.C.'s " representing and fighting for their political and business rights.

Since the discussions and debates in the " F.C.'s " should exclude all party political matters and should be essentially of an educational character, the N.F.U. will continue to serve its main purpose. But it will be of special value that master and men will be members of the same organization, the " Farm Communities " and will thus be brought together on an equal social basis. This will bring about a closer relationship and a better understanding of the other man's case, and so do something to avoid quarrels arising from biased views.

To the same extent the N.U.A.W. should remain the political and economic executive organ of the farm worker members of the " F.C.'s ".

But all matters concerned with education—vocational and liberal, economic and social—should be left entirely to the common organization for all rural people, the " Farm Communities," and, on the other hand, these themselves should be kept free from all purely political and purely business issues.

The function of the " F.C.'s " will be to educate their members—farmers and farmworkers alike—so that they can understand and grasp fully the economic, social and political conditions of the past and present and by so doing to enable them to take an intelligent part in the transactions of their respective ' trade unions,' the N.F.U. and the N.U.A.W. Such a disinterested and, as far as possible, objective instruction in these subjects is, in our opinion, to be preferred to one given by the " Trade Unions " themselves. This is one more reason why we propose to make the " Farm Communities " the central body in the framework of the rural organization.

2. *Co-operative Associations, etc.* We have shown above that one of the tasks of the " F.C.'s " should be education for co-operation in all spheres. The members of the " F.C.'s " should be stimulated to undertake co-operative enterprises and trained to partake intelligently in such undertakings.

But we are of the opinion that " F.C.'s " should not themselves actively undertake any co-operative enterprise. " F.C.'s" should give active support to the foundation of necessary co-operative enterprises, like Machinery Pools, Bull-Schemes, co-operative Pasteurisation Plants, etc. Such enterprises should be undertaken by separate units, by co-operative societies and associations. The essential task of the " F.C.'s " should not be entangled with business enterprise. If a local " F.C. " were to start a co-operative enterprise, this enterprise would of necessity become its first concern and the main task to be performed by it would suffer serious harm. The F.C.'s " should, by instructing their members and by educating them to local leadership, build up the human material required to run such co-operative undertakings. There should, of course, be close contact between the " F.C.'s " and co-operative associations, even leading to a personal contact between their officers, but both bodies should remain as separate entities. By stimulating the co-operative enterprise of their members, the " F.C.'s " will themselves benefit, because their members will then learn by practical experience what they have been taught as members of the " F.C.'s ".

On the other hand, the starting of co-operative undertakings by members of the rural

community without the instruction and the necessary background which we suggest that the "F.C.'s" can provide, might easily lead to disaster and bring the whole agricultural co-operative movement into disrepute.

Thus, the "F.C.'s" will act as a basis from which the agricultural co-operative movement—"the organizing principle of the new agriculture"—will take its strength and stimulus.

3. *Chambers of Commerce.* There should also be close contact between the rural community and industrial and business interests. We have spoken above about the close relationship in modern times between all the branches in a national economy. Therefore, the members of the "F.C.'s" should have first-hand information about the development in the other branches. We suggest that this information could be given to the "F.C.'s" through the establishment of liaison officers between the "F.C.'s" and the Chambers of Commerce. In addition, there should be common meetings devoted to instructive talks and lectures, so giving the members of both organizations an insight into the activities of their respective fields.

The writer hopes to have shown that the proposed development of the 'Farming Clubs' now in existence into a nation-wide organization of 'Farm Communities' will serve to establish a well-organized, balanced and healthy rural life, held together by a common bond of mutual respect, understanding and confidence, and that this development can be achieved without detriment to existing voluntary organizations. On the contrary, it is maintained that, by making the 'Farm Communities' the focal points and essential links between all the organizations concerned, these bodies will receive additional stimulus and will prosper by supplementing each other and so forming a homogenous, co-ordinated and integrated whole.

It is submitted that the present time, when all minds are keen and alert, should be used to further actively such a programme and to lay the foundation stone for the suggested movement. It would be a pity if the seeds sown in the field of rural adult education during the war were not brought to maturity and gathered to the benefit of the whole country.

G. P. HIRSCH.

1, Brookfield,
Newnham Walk,
Cambridge.

Literature

'*Avoncroft*' (booklet by the Avoncroft College) 1944.

Dr. W. F. BEWLEY, *Mutual Aid Groups*, Fruit-Grower, 6.4.1944.

C. KINSEY, *Discussion Groups*, Herefordshire Agric. Journal, Jan. 1944.

W. H. PEDLEY, *Labour on the Land.*

D. B. JOHNSTONE WALLACE, *Agricultural Discussion Societies*, Agricultural Progress, 1924.

GLADYS BAKER, *The County Agent.*

SOLON JUSTUS BUCK, *The Granger Movement.*

JOSEPH W. EATON, *Exploring Tomorrow's Agriculture.*

GEORGE H. REUSS, *Adult Education in the F.S.A. Programmes.*

U.S. Department of Agriculture Publications :—

A. C. TRUE, *A History of Agricultural Education.*

—— *A History of Agricultural Extension Work.*

Extension Service Circulars Nos. 397, 402, 409.

1940 *Yearbook of Agriculture.*

WORKS AND LESSER, *Rural America Today.*

W MORLEY DAVIES, *The organization of Farm Experimental Work in Germany*, Agricultural Progress, 1930

PROF. W. G. S ADAMS, *The Social Consequences of Agriculture.* Scottish Journal for Agric., July 1944

—— *The Progress and Work of Rural Community Councils*, Journal, The Farmers' Club, Part V, 1929.

PROF A. W. ASHBY, *Policies and Programmes of Young Farmers' Clubs*

—— *The Social Purpose of Adult Education.*

—— *Sociological Background of Adult Education in Rural Districts.*

F. M. FOSTER, *School for Life—A Study of the People's Colleges in Sweden*

GALPIN, *The Social Anatomy of a Rural Community.*

G. H. GARRAD, *Single Lectures for Adult Farmers*, Agric. Progress, 1924.

DUNCAN McGUFFIE, *Science and the Farmer*, Agriculture, Dec. 1944.

E. SEWELL HARRIS, *Community Centres and Associations.*

SIR RICHARD LIVINGSTONE, *The Future in Education.*

MOELLER AND WATSON, *Education in Democracy.*

HAROLD C. SHEARMAN, *Adult Education for Democracy.*

U.S. Department of Agriculture (Office of Plant and Operation) *County Agricultural Buildings.*

LAND SETTLEMENT IN ENGLAND

The effect of war always seems to be to stimulate a demand to settle on the land. Many men who might never have thought of doing so in peace-time come, in war-time, to think that is what they would like to do after they have done with fighting. Some townsmen, who had long cherished a dream of being able one day to settle on the land, hope that the chance may now have come. Some countrymen and wage-earners who had not been able to save the capital necessary to set up on their own account trust that their war gratuity may now enable them to do so.

With many of those ex-service men who were formerly employed in urban occupations the motive for seeking a new career in the country may be little more than a vague idea that life would be pleasanter and more free from the irksome conditions of wage-earning employment in a factory.

Whatever the reasons for it are, there is no doubt that the demand is there. Everyone who is in touch with men serving in the armed and civil defence services knows it. It is sufficiently extensive to justify or rather require that it should be taken seriously. Men with little or insufficient knowledge are looking out for plots of land and even getting their relations to buy on their behalf. Unscrupulous speculators are ready to take advantage of this opportunity to sell plots of poor land for good prices. Many such men, in spite of warnings from those who have some knowledge of the difficulties which confront the small holder, may invest their savings in unsuitable land and find, too late, that they cannot make a living. If no plan is adopted to deal with this demand much discontent will be roused among many thousand men and indeed women, and there will be lamentable failures among those who have gone ahead and tried their luck.

On these grounds alone there is a strong case for devising machinery for making the best advice available to men who seek it and giving those who are determined to acquire a holding all the help possible, and for impressing on every man who contemplates settling on the land the real nature of the difficulties he will have to meet. But there is need for more than that. This impulse to settle on the land raises an issue of deep social significance. However light-hearted or superficial may be the reasons actuating many of those who think of a pleasant life in a country cottage in contrast to that of factory or office, it nevertheless represents a widespread and instinctive urge for freedom, for being your own master, for ceasing from spending your life being ordered about. This is a perfectly legitimate and respectable desire. If we believe in democracy and in respect for the individual, and if we think public policy should be so directed as to encourage men and women to stand on their own feet and live as free lives as possible, then we should surely respect that desire and even welcome it. It represents the very thing on which strong character can be built, the very thing which the democratic idea stands for and the autocratic, authoritarian idea repudiates. There is to-day in the world of industry and commerce a certain conflict between those who aim at the creation of large organizations employing thousands of men and those who want to see the small man survive. This issue is commonly discussed in terms of economic values. In a competitive world economic considerations must be given due weight, but not to the total exclusion of human ones. Belief in the value of the small man is not merely sentimental. It may well be that the development of a healthy and intelligent community, of a self-reliant democracy depends as much on the retention of scope for the individual to live his own economic life in his own way as on efficient large-scale organization. It

looks as though both are needed and if that is so it becomes a matter of first-rate national importance that the growing impotence of the small man in competition with the large organization should be examined so that steps can be taken to preserve an economic field in which the small man can find liberty to live in his own way and scope to render his own special contribution to the life of society.

It is not only those who have been uprooted from their normal lives to serve in the armed forces who need consideration. Always a proportion of those who have been born and bred in the country and have entered the service of agriculture at the bottom want some day to have a holding of their own. The realization of this ambition has been difficult in the past in spite of the facilities provided by the Smallholding Acts. For a wage-earner in agriculture, with a family to support, could hardly hope to save enough money to equip and finance a holding large enough to yield a full living—even at best—before he was well advanced in years. Some did so, either by obtaining help from friends or relations or by first acquiring a small plot which they worked in their spare time and then gradually increasing their stock or their cultivations. But if the needs of the countryman are really to be met it should be possible for him to obtain a holding while he is still in the prime of life, while his children are young and he and his wife can together earn a living and create for themselves and their family a life which is not a mere struggle for existence overshadowed by the need for incessant scraping and the fear of failure.

There are then two aspects of the problem of land settlement—the demand from serving soldiers, sailors, airmen and women on the one hand and from permanently established countrymen on the other. For the time being the principal existing scheme for meeting this demand—the County Councils Smallholding Scheme—is suspended and there is no immediate prospect of its being again brought into operation.

The time, therefore, is opportune for considering what principles should guide future policy: what should be the scope and purpose of a land settlement scheme and whether the Smallholding Acts need amendment in order to perform a clearly defined function within a broad national social policy as well as within the more restricted field of agricultural policy.

The Scope of Land Settlement Policy.

Before discussing the actual issues involved it is important to be clear as to the extent of the problem to which the term "land settlement" applies. To arrive at a definition it is necessary to record the change which has been taking place in informed opinion about the relations of town and country; the effect on urban social conditions of recent advances in industrial technology; the growing realization of the unsatisfactory standard of housing and health among our urban population and of the influence of new methods in education on social habits.

After a long period during which the life of town and country became more and more divorced a contrary movement has now set in. Instead of the population moving steadily away from the country into more and more congested towns, as was happening throughout the nineteenth century, the inhabitants of towns have been emerging into the country and spreading untidily over larger areas. Consciousness of the evils resulting from the concentration of factories and commercial offices in towns led the Barlow Commission on the Location of Industry to recommend that national policy should be directed towards deflecting industry from the larger centres and securing its more even distribution throughout the country as a whole. The impetus which the war has given to the idea of better urban planning, while perhaps not strong enough to achieve all that is hoped, will certainly result in a clearance of some of the most congested areas in towns and provide more space to be used for various kinds of recreation.

The development of industrial processes and particularly of production by repetitive methods may well have two effects ; to make it possible to meet the capacity of the market to absorb the goods produced by less expenditure of manpower and to stimulate a demand for shorter hours of work. The raising of the standard of education may tend to produce a similar demand. As men become more mentally alert and better informed more of them are likely to be reluctant to spend a large proportion of their lives in earning their living by work which makes little or no appeal to their intelligence.

These various influences appear likely so to operate as to increase leisure and so create a vacuum which must be filled. If in the process of reconstruction we concentrate our minds too exclusively on getting the wheels of industry and commerce going again, or indeed on making everyone economically secure, we shall be in danger of creating grave social problems. To illustrate this risk it may be pointed out that probably much of the existing demand from men in the armed and civil defence forces for opportunity to settle on the land is prompted by an instinctive desire on the part of those who were previously townsmen for a more spacious way of living. It springs from discontent with the confined life of streets, from a legitimate wish to give better and healthier conditions to children, from an aspiration for a fuller and more satisfying and more varied way of life. This is not just a passing phenomenon. Failure to recognise it and meet it must result in social unrest. It is not a mere platitude to say that one of the most baffling problems of the future looks like being the employment of leisure.

All these various considerations lead up to the question, what part can the land play in providing a solution ? Can we plan, for instance, far more consciously and deliberately than we have done in the past for land to be treated in the future as one of the means whereby a solution can be found ?

The dispersal of industry will result in factories being erected in areas where land can be made easily available for cultivation by workers as a bye-occupation. The application of town planning principles will result in the inclusion of larger spaces within the confines of towns which could be similarly used. The development of the practice of the cultivation of land by town workers can provide a strong bulwark of defence against the worst evils of unemployment or under-employment and so further the policy of social security. But the realization of these ideas depends upon whether in fact town workers want to cultivate land in their leisure time. To this a partial answer can be given. The experience of this war and the last has shown that large numbers of townsmen are ready to cultivate gardens when the need arises. In peace-time, no doubt, many will cease to do so voluntarily. Others want to continue and many will be unable to do so because the land will be required for other purposes. Taking the country as a whole, before the war, the demand from townsmen for allotments was considerably in excess of the supply. In certain parts of the country, and particularly in coal mining areas and districts where the local industry is liable to regular seasonal depression, the demand for land to cultivate has been persistent and seldom fully satisfied. The experience of some, at least, of those businesses which have been evacuated from London has been that a number of their employees have discovered the pleasure of gardening and will be reluctant to return to conditions that make its pursuit impossible. Broadly speaking few people enjoy idleness or time which they cannot actively employ. Of all kinds of hobbies to which men turn, gardening in some form is probably the most popular. If, therefore, we are to find satisfying uses for leisure time, land for town workers to cultivate is certainly one important means of doing so.

To include the part-time cultivation of land in the definition of land settlement may seem to be extending too widely the scope of the discussion. It is, therefore, worth while summarising the reasons for doing so. The demand for facilities to settle on the land is not entirely a phenomenon produced by the war but is to some extent prompted by discontent

with urban conditions of life. Improve those conditions and create extensive facilities for the townsman to satisfy his need for a constructive hobby and a considerable step will have been taken to meet a widespread need which is better satisfied in this way than by opportunities to settle either as a smallholder or even as a wage-earner in agriculture. The extension of part-time cultivation involves market gardening and possibly poultry keeping; perhaps pig keeping. These forms of production need proper supervision. Stock especially must be carefully looked after if risks of disease are to be avoided. The volume of production from this source in the whole country may become substantial—it has become substantial during the war—and it should be watched from the point of view of production generally. The sale of produce surplus to the home requirements of the producer must not be allowed to undercut prices for those who derive their full living from similar enterprises. Thus a land settlement policy in its full sense means a policy which will meet the demand for the use of land both as a means of earning a full living and for land to cultivate as a bye-occupation whether by countrymen or by townsmen. Such a policy should be controlled and directed in accordance with definite principles designed to further the social welfare of the nation.

The part-time cultivation of land by townsmen involves the production of considerable quantities of food-stuffs and raises questions concerning the hygiene of small stock keeping. It should, therefore, be included within the orbit of a policy concerning small scale production and should be properly supervised and guided under the general supervision of the Ministry of Agriculture.

The Purpose of Land Settlement.

Using the term in the broader sense suggested above the purpose of a policy of land settlement must be principally, though not exclusively, social. It is on grounds of personal well-being, of considerations concerning the relation of the individual to society and of the health of the community as a social unit that a decision must mainly be made. Mainly, but not exclusively. The small farmer, for instance, constitutes an important element of stability in the economy of agriculture. As was pointed out by Messrs. Orwin and Darke in their book " Back to the Land " which was written as a criticism of the proposal to attempt to establish unemployed industrial workers as smallholders, " the family farmer, the real smallholder, is of fundamental importance in British rural economy. Indeed he is its most permanent constituent member ". . . . . " his position gives him a stability which few producers of primary commodities enjoy " . . . . " if times are bad the margin between receipts and payments may be very small, but there is generally something and his expenditure on his own living is adjusted accordingly. He knows nothing of the dead weight of the weekly wages bill . . . "

Thus the small man performs a definite economic function and this should not be forgotten when we consider whether or no agricultural policy should include a measure of land settlement. We are entering upon a new economic epoch. We cannot be sure that some of the articles of faith which have dominated economic thinking will not prove illusory in the future. It may even be that further experience may modify the views of those who to-day believe firmly in the value of large-scale organization, for large units have their Achilles heel as the unemployment crisis of the decade before the war indicated. This is not to argue that a policy of land settlement should be adopted on economic grounds, but to bring out the fact that even on economic grounds some arguments can be adduced in favour of a policy which aims both at strengthening the position of the small man and of maintaining a proportion of small producers.

But, even if that is true, the arguments in favour of a policy of land settlement must be conceived in terms of human needs rather than in those of material considerations.

Our national life is built on belief in the value of the individual. In the past we have often allowed ourselves to forget this. In the delirium produced by new discoveries, in the visions of wealth and power which they conjured up, we allowed regard for the welfare of the individual, as a person, to be subordinated to the claims of industry and trade. In due course the inevitable results ensued. We have had, and still have, to pay a heavy price for that neglect. There is a grave danger now that in preparing to meet the competitive conditions of the post-war world our national policies will again be determined too much in the light of economic considerations and too little in those of human welfare. How does this apply to agriculture? So far as the conditions are concerned under which the bulk of those engaged in the industry have lived, they have been grossly neglected in the past. Relatively speaking, little has been done during the last fifty years to create in the countryside an environment in which men and women would become fully responsible citizens and fully developed individuals. If we now concentrate our minds too exclusively on questions of increased production and better agricultural organization we shall not be developing the one thing that ultimately is the most important of all—a rural community of which the members are conscious of their responsibility to society, who know and feel that, as individuals, they are of importance in the structure both of the industry by which they gain their living and in that of the state of which they are citizens.

In other words if we are to have a prosperous agriculture we must bring into and retain in it, not only as land owners or as tenant farmers, but also as workers, men and women of quality who can find in their work and in their life full opportunities to discover their powers and realise their ambitions. Here are to be found strong grounds for a policy of land settlement. While there are many men who are satisfied with and indeed prefer to be employed on a wage-basis, there are others whose ambition it is to be independent. If one purpose of enlightened government is to secure as far as possible the full development of every individual, then the needs of this particular group should be met. Many of such men value independence more than high material reward for their work. They are potentially a valuable element of society and if they cannot find the opportunity they seek in agriculture they will tend to seek it elsewhere. Given a fair prospect of obtaining a holding of their own at a reasonable time of life, they will be more likely to remain in agriculture and to make their contribution to the stability and variety of the rural community. To provide for their needs is to act in the interests of agriculture as an industry. For it is not to its advantage that men should leave it because they can see no hope of realising their ambitions or that the children who might have adopted agriculture as a career should go away to earn their livings in office or factory.

For a long time past men have been abandoning agriculture, not only because wage rates were unattractive but also because conditions of life in the country were incompatible with the standards which have become established by better education and improved conditions in the towns. Women are less and less ready to tolerate the lack of normal domestic amenities prevailing in too many villages. The educational facilities open to the children of country people are on the whole inferior to those available to town children. Access to places of higher education is more difficult. Medical and other social services are less well distributed in country districts.

A higher rate of wages will not alone be sufficient to counteract the influence which these disadvantages exert on parents and on children in the choice of a future career, and agriculture will continue to compete at a disadvantage with other occupations for the retention of young men of energy and ambition and for new entrants. It is even questionable whether the wage rates after the war will be maintained at a level comparable with those prevailing in urban industry. The demand for labour to meet the needs of all kinds of manufacture is likely, at least for some years to come, to be considerable. This will tend

to keep urban wage-rates high. Moreover, urban industry is more exposed to and responsive to pressure from organised labour than agriculture. Consequently there is a strong likelihood that the gap will again widen between the wage rates paid in the two types of production. Thus agriculture will need all the help it can get if it is to compete on approximately even terms with urban industry for the services of men of quality. It has been observed too that one attraction of the town has been the greater, or presumed greater, opportunity it provided for a man to set up in business of some kind on his own account. If agricultural policy included satisfactory provision for helping men to independence at a reasonably early age this influence would to some extent be overcome and the attraction of the industry as a career would be appreciably increased. In the interest of agriculture itself, therefore, land settlement has a function to perform and one which might in time have a powerful effect in bringing into and retaining in the industry and in the countryside the men whose independence of character and energy give them a special value.

Thus in addition to the main social purpose of a land settlement policy there exists what can legitimately be called an economic purpose and one of considerable importance when the stability of agriculture will depend in this country on high quality of production and the intelligence and resource of those engaged in it.

If, however, the main purpose of a policy of full-time smallholdings must be the satisfaction of a social and personal need, the same applies even more to part-time holdings, both in the country and in towns. If greater facilities were provided for enabling the agricultural worker to obtain the capital he requires in order to finance a full-time holding it is possible that the demand from men of that kind for part-time holdings would diminish. It would, however, still exist. Many countrymen are reluctant to leave the district they know in order to take a holding away from their friends and amid unfamiliar conditions and are likely to prefer building up their resources through the medium of a piece of land which they can look after in their spare time, to embarking, at a single step, on a full-time holding with borrowed money. In towns the problem is different. Very few of those who want a plot of land to cultivate contemplate taking up agriculture as a career. They want it because they enjoy the work and also because of the food it can supply for their households cheaply, and, in some areas, because many men, and particularly the older ones, are still haunted by the fear of unemployment and see in a plot of a quarter or half an acre a very real means of contributing to the support of their families should they fall out of work.

Briefly summarised, the purpose of a policy of land settlement as defined above must be partly to remove the obstacles which prevent the wage-earner in agriculture, who wishes to become an independent producer, from realising his ambition; partly to raise the status of agriculture as a career by creating the attainable goal of independence for those who desire it; and partly to open up for townsmen a wider field of interest and occupation and, to those who have the inclination, a subsidiary means of support.

The Difficulties to be Overcome.

(*a*) *Full-time holdings*:

The difficulties to be overcome in establishing a successful scheme of smallholding development are of two kinds, firstly administrative and financial and secondly personal and individual. At the present moment the administrative difficulties are formidable. There is, for instance, no free land available as there is in a new country, so that land to be used for this purpose must be acquired from existing owners and devoted to a different kind of production. Good land is necessary. If a man is to get an adequate living from a small area it is useless to give him poor land—and good land is expensive. For some time to come the building industry will be overwhelmed with work; no spare labour is likely to

be available and the lay-out and equipment of a smallholding estate, with its houses, outbuildings, roads and services demands a large amount of labour. And again costs are likely to remain high. Before the war the cost of establishing an equipped holding on one of the estates of the Land Settlement Association was just under £1,000 ; today it might be twice as much. Because of the difficulty of releasing labour and materials for the purpose the Ministry of Agriculture hesitate to remove the embargo on the extension of the County Council Smallholding scheme. Yet it must be borne in mind that the problem cannot be looked at solely as one of labour and materials. We are committed to a policy of a prosperous agriculture, and agriculture cannot be prosperous unless and until a large number of new houses are erected for those employed in the industry. To subordinate the claims of the countryside unduly to those of the town is to injure agriculture and to postpone the realization of agricultural prosperity. And houses erected in connection with a smallholding scheme not only constitute an indispensable part of the scheme but contribute towards the process of rehousing the countryside. A smallholding scheme is a housing scheme, just as much as a scheme to erect a row of cottages. When, therefore, the time comes for proceeding with rural housing, land settlement should not be deferred on the ground that it deflects labour from a more urgent task, for, on the contrary, it will be contributing to the very purpose in view.

The fundamental difficulty really is that smallholdings are not regarded as being capable of yielding an economic rent on the outlay. Of the capital expenditure incurred after the last war on the smallholdings established for ex-servicemen a large proportion was written off when the holdings were transferred to the County Councils in 1926. That is a memory which lingers. Between 1926 and 1939 the annual provision of new equipped holdings was not large, and many County Councils now obtain a sufficient rent from their estates to cover expenditure and meet the interest on capital, but that is not to say that the return is economic since some of the original expenditure on the holdings established after 1918 was written off. Probably the data do not at present exist on which to form a definite opinion whether smallholdings can be established on an economic basis or not. We do not know what will be the level of agricultural prices. The cost of land and buildings may fall within a few years. It should, however, be emphasised that if, under the conditions prevailing prior to 1939, the rents of smallholdings were not fully economic, it does not necessarily follow that they could not be, under different conditions. We had not reached finality in our ideas as to how smallholding schemes could best be planned and it may be that there are ways and means by which the yield of holdings can be raised and their capacity to provide an economic return increased. If it is accepted that smallholdings can be an important element in the prosperity of agriculture as well as an important factor in social well-being, then careful study should be given to the best methods of establishing and administering them. In the process of doing so it might be found that, once prices have reached a more stable level, they are not necessarily so uneconomic as they are sometimes held to be. Such a study will involve the consideration of the personal difficulties with which the smallholder is confronted once he enters into occupation of his holding. These can roughly be summarised under four headings, *viz.*, technical instruction and guidance ; working capital ; buying and selling ; mechanization.

Technical instruction and guidance: Under this heading there should be included the planning of the production scheme. A smallholding presents a different problem from that of the moderate-sized or large farm. It should not be a large farm in miniature. The training a man receives as a worker on a farm does not necessarily equip him with the particular kind of knowledge he needs successfully to exploit a smallholding of whatever nature it may be. It gives him the background of knowledge and experience on which he can build, but as a smallholder he will need a higher degree of technical knowledge and will

meet problems of management which are new to him. In the first place, therefore, holdings should be carefully planned for a specific kind of production. This is most important if the high standard of production is to be achieved which alone can yield a satisfactory livelihood to the smallholder. In the second place the smallholder should be able to call upon expert advice on both the technical and managerial aspects of his enterprise. On the estates of the Land Settlement Association staff were appointed to train and guide the inexperienced townsmen who were the first settlers. It was then believed that, after a period, the services of the technical advisers would be able to be withdrawn and that such advice and help as could be obtained from the County Agricultural Organiser and his staff would meet the needs of the smallholders. Experience has shown this anticipation to have been incorrect. In recent years several hundred countrymen—including a majority of agricultural workers—have been admitted as tenants, yet the need for the services of technical advisers resident on the estates has not diminished. It is true that the experience of the farm hand would not be expected to give him the knowledge he needs successfully to manage a holding based, as are those of the Association, on horticulture, pigs and poultry, but this is true of other types of holding as well. The agricultural worker has not received the education and training which would enable him to keep constantly abreast of new knowledge, nor indeed has he the time. He cannot deal unaided with the frequent technical problems that arise on every type of holding. His first and principal need, therefore, is for skilled advice, readily available.

Working capital: Lack of sufficient capital is one of the most frequent causes of failure of the small producer. It is the lack of it which prevents many an able agricultural worker from realising his ambition of obtaining a holding of his own. It is insufficiency of capital that prevents a man from equipping and stocking his holding adequately and that makes it difficult for him to tide over periods of difficulty and adverse conditions. On the other hand, it has been impossible in the past for a man earning the weekly wage of an agricultural worker to save a sum large enough to finance a full-time holding until he is past the age of full vigour. During the war many agricultural workers have saved money and their friends and relations have done well, perhaps in other occupations. The result is that there are to-day many applicants for smallholdings from among agricultural workers who can lay their hands on the capital they need. Nevertheless there are still many who cannot do so. Of the new tenants admitted by the Land Settlement Association during the war approxiately 68 per cent. have taken advantage of the loan scheme which has been arranged with Barclays Bank. Many excellent men with every qualification for success do not possess, and cannot find, more than a sixth or so of the sum required fully to finance a holding. Under the Association's scheme the Bank undertakes to advance, without guarantee, up to 50 per cent. of the amount required. This amount is secured as a floating charge on the tenant's stock and equipment. The further security they possess resides in the care taken in selection of tenants and in an undertaking by the Association that they will keep an eye on the tenant and, should the standard of his husbandry give cause for anxiety during the currency of the loan, that they will communicate with the Bank. Should a loan be required in excess of 50 per cent. of the total working capital the Association are enabled by the Carnegie United Kingdom Trustees to guarantee the Bank against loss in respect of the balance. It is believed that an arrangement of this kind could be extended and that banks would not be unwilling to advance loans on similar terms if, for instance, County Councils were prepared to undertake the responsibility of supervising the holdings of borrowers during the currency of their loans. If this were, in fact, found to be practicable little risk would fall on public funds and smallholders would be relieved from their dependence for credit on their suppliers, as is now generally the case.

Buying and selling: Hitherto little attempt has been made to develop centralised buying

and selling among smallholders. Some do belong to co-operative societies which mainly concern themselves with the purchase of commodities and little with the selling of the settlers' produce. The Milk Marketing Board provide the selling agency for small as well as large milk producers and as such have strengthened the position of many smallholders. But if a fresh approach is to be made to the smallholding problem—and it will not be possible indefinitely to hold up the operation of the Smallholding Acts—a deliberate part of policy should be to develop co-operative buying and selling. The smallholder is heavily handicapped at present. Since he buys relatively small quantities of feeding stuffs, fertilizers, seeds and so on he pays more for them than the man who buys in bulk and, what is equally important, he has less guarantee of obtaining good quality. On the selling side the handicap is even greater. His bargaining power is small; the quantities he has to offer may not be such as greatly to interest buyers. If he is a market gardener he cannot guarantee a constant supply, which is what a selling agent requires. He thus tends always to get a lower price than his larger neighbour. It may be that public authorities cannot themselves undertake to organise buying and selling on behalf of smallholders but they could promote the formation of co-operative societies; they could provide information on co-operative methods; they could in fact undertake educational work on the subject.

Action of this kind has been taken on an extensive scale and with considerable success in the United States as part of the campaign to improve the economic position of the small farmer, and there is no reason why it should not be done here. The example set by the East Sussex W.A.E.C. in appointing supervisors specially to advise small farmers and to promote co-operation might also with advantage be widely followed.

The development of organised selling would perhaps do more than anything else to strengthen the economic position, at least of certain types of smallholders.

Mechanization: For many smallholders the problem of getting heavy cultivations done at the right time is a serious one. They may not be able to afford to buy the implements required and, if they do, depreciation is heavy in relation to the volume of production for which the implements are used. If they rely on contractors, as they frequently must, they are at a disadvantage, since their custom is of less value than that of the larger farmer and they are less likely to get the service they require at the time they need it. Here the solution may lie principally in the direction of the production of implements specially suitable for the small farm and in a greater standardization of those implements. The multiplicity of types, none very different from the other, develops faddiness in the buyer and so creates a vicious circle. The buyers have preferences that may not be so important as they think and the manufacturers attempt to meet this varied demand. This inevitably results in higher costs. An educational campaign on the subject, together with a drive by the manufacturers to achieve greater standardization, might benefit both the small farmer by a reduction in the cost of production and the manufacturers by an increase in sales. Possibly, too, the development of co-operative habits would help to ease the position. In America the co-operative purchase and use of implements has been considerably encouraged.

So far little mention has been made of management problems, but this is a side of his work in regard to which the small man might get considerable help from expert advisers. Here again the experiment made by East Sussex is significant, and the experience of the Land Settlement Association also indicates how much the agricultural wage earner, who becomes a smallholder, can benefit by advice on the planning of his work; on finance and the keeping of simple accounts. It is not easy for a man accustomed to living on the basis of a weekly wage to adapt himself quickly to a totally different economy. Few men who become smallholders have much knowledge of account keeping, but a simple form of accountancy can be easily devised and can be an important factor in enabling the small

man to frame his budget, determine his financial position and base his plans on reliable data.

The policy adopted in regard to smallholdings in the past has largely been to leave men to sink or swim. They have been selected, often with considerable care ; the authority concerned has satisfied itself that they had some capital, but after they have taken up their holdings they have often been left largely to themselves to manage as best they can. There is much to be said for self-help and self-reliance, but such a policy is not likely to result in a high standard of technical efficiency, progressive methods or a satisfactory standard of life for the smallholder. In Denmark, in Holland, in Belgium, the small man finds support from various forms of co-operative organization. He obtains technical advice, financial advice and help in buying and selling. Those services have been little developed here. Until an attempt has been made to develop them we cannot say either that smallholdings necessarily involve a low standard of husbandry or that they are uneconomic. If for the reasons outlined above a new smallholding policy is undertaken as part of both social and agricultural policy, it is essential that the smallholders should have the services they need if they are to play their part in production and to earn a living which is compatible with modern standards.

(*b*) *Part-time holdings* :

The problem of the part-time holding is rather one of land use than of land settlement. It concerns both the countryman and the townsman. A large proportion of the County Council Smallholdings are part-time holdings and when the time comes to re-open the County Council scheme consideration will have to be given to the purpose which part-time holdings in country districts—other than allotments—should be designed to meet, if greater facilities are provided for the agricultural worker to obtain a full-time holding.

But the more difficult and larger problem is that of the townsman. There can be little doubt that as a result of changing economic industrial and social conditions land will be required in the future for townsmen to cultivate far more extensively than in the past. The question is not merely one of allotments. There is a demand also for larger plots ranging in size up to half an acre. Many thousands of such larger plots have been provided by the County Councils of Durham, Monmouthshire and Glamorgan and by the Land Settlement Association in the northern and midland counties. During the two German wars great encouragement was given to the allotment movement, to backyard poultry keepers and small pig keepers, and the restrictions that prevailed in peace-time on the keeping of small stock in towns were relaxed. But when normal conditions return and the urgent need for the home production of food no longer exists the interest of public bodies tends to flag and the demand of the townsman for land to cultivate tends to be subordinated to other purposes for which land is required by urban authorities.

The difficulties in the way of meeting the needs of townsmen are great. Land in the neighbourhood of any town is expensive. Most urban authorities are now framing planning schemes which will involve heavy commitments. No decision has yet been made by the Government on the subject of compensation and betterment which was examined and reported on by the Uthwatt Committee. Prejudice against allotments also exists, not altogether without justification. On the other hand, those interested in the Allotment movement feel that their claims are not being given the consideration due to them. In many areas land is provided for the purpose only on a temporary basis. There is no security of tenure and immediately land is required for building or other objects the allotment holders are displaced.

Before the war the number of allotments in the country generally was diminishing, not because the demand was falling off—it was continuously in excess of the supply—

but because the land was being taken for housing or roads or other public uses. A new outlook on the whole subject is required. The issue concerns a number of different Government Departments. In the plans that have been made for a progressive policy in education stress is being laid on the need to use practical activities more extensively as a medium of fostering powers which cannot be cultivated by book knowledge alone. Most children respond at a certain age to the appeal of gardening and of looking after animals at least sufficiently for a realization to germinate in their minds of the relationship between the earth and the food they need and many find through it interests which affect their whole subsequent life. If the children in our towns are fully to experience this form of education there must be space for gardens adjoining or near to the schools. The problem thus concerns the Ministry of Education. It concerns also the Ministry of Health. Before the war it was discovered that a disturbingly large number of the people of this country were ill-nourished and, naturally enough, it was among the lower paid sections that the diet was found most often to be deficient. Some measures have already been taken to overcome this evil, but there is still need to increase the consumption of, for instance, fresh vegetables, fruit and eggs—articles of diet which can be home produced wherever land is available. One way, therefore, of improving the nutritional standard of the population is to see that all who want a plot of land to cultivate can get it.

The difficulties in the way of the practical realization of a plan to provide townsmen with land to cultivate are not insuperable if once the importance of it were recognised. That recognition still tarries and a lead is required from the departments on whom responsibility rests for defining policy.

Local authorities, confronted as they will be with new and absorbing problems of reconstruction, are unlikely to become fully conscious of the important part land can play in the future life of the towns unless their attention is drawn to it by the central organs of government. What is needed is that the departments concerned—the Ministries of Agriculture ; Education ; Health and Town and Country Planning—should jointly agree on a policy and make their views known to local authorities.

Conclusion.

There can be little doubt that with the end of the war we are entering upon a new era in which great social and economic changes will be occurring. It is not within our power to prevent them ; but it is within our power to observe and determine the main trends of change and to adapt our social and economic policies in such a way as to advance the principles on which our social life is built and for which we have fought.

We have nailed our flag to the mast of democracy. If that means anything it means that national policy must be based on respect for the individual; that all policy should be so directed as to favour the growth of the individual to his full stature. This involves a mutual relationship between the individual and the community. The individual cannot grow outside the community: he must, therefore, accept in an increasing measure responsibility for framing policy and for directing administration. This implies that he must develop the capacity and the readiness to co-operate.

Applying these principles to the problem of land settlement the decision that has to be made is whether they indicate that it is in the interests of society that opportunity to realise their ambition should continuously be provided for those who, starting life as wage-earners, desire to become independent producers. If the answer is "yes" the next step is to determine how this object can be attained on an economic basis. We cannot escape from competition. We cannot afford a land settlement scheme which does not provide for the art of food production to be performed on the basis of the highest possible technical skill and for the produce to be sold by the most intelligent methods. A land settlement

scheme, too, needs to be integrated with food production policy generally and to be planned in relation to a general scheme for raising the technical efficiency and standard of life of the small producer. This means in one word the encouragement of co-operative methods. Such encouragement cannot be left to chance. If we are to educate producers in co-operative methods we should set about it systematically. Here is a function which the county agricultural authorities, which replace the War Agricultural Committees, should be well suited to perform. If smallholding schemes are in the future to be planned on the basis of co-operation the county authorities must employ staff whose main duty it would be to advise on co-operative methods and the functions of that staff would be extended to cover all small producers in their areas and not only the county council smallholders.

The function they would perform would not only be an economic one. It would also be a social one. The smallholder or small farmer leads an isolated life and is apt to concentrate his mind and his interests on his own affairs to the exclusion of his responsibilities as a citizen. If we are to improve our system of local government in the counties we must cultivate the feeling that individuals have a function to perform in society and a responsibility for the affairs of the community. By developing co-operation the small man can be led to take part in the work of a group and so brought to feel the importance of the part he can play in its work. Co-operation performs, in fact, an educational function which can help to foster a more alert social consciousness and greater participation by the individual in public affairs. In the organization of land settlement on co-operative lines lies the germ of a process which could have a wide educational influence both on agricultural development and on the social and political awareness of those who live in the countryside.

In discussing land settlement it has been contended that the term should be taken to include land used by townsmen. There is nothing new in this. What would be new would be a definite policy for promoting land-use by townsmen. Already the Ministry of Agriculture and Fisheries is the government department charged with the supervision and the administration of the Acts relating to allotments. It is, therefore, already open to them to formulate a policy. Now is the time for it, when the future planning of our towns is being studied and the effect of industrial and social change can be related to the future probable needs of urban populations.

Neither land settlement for the countrymen nor land-use for the townsmen presents problems of such political or economic magnitude as to loom large in public discussions to-day. They are consequently both liable to be pushed into the background as matters of secondary concern. Both, however, represent issues of great and primary social importance.

We have long formed the habit of determining policies in the light of industrial, commercial and financial considerations. When excessive concentration on those issues has resulted in grave social evils and injustices we have been forced to adopt measures, often at vast expense, to remedy them. It is time we learnt our lesson and studied our plans for post-war reconstruction in the light primarily of human needs—the need, that is to say, for full personal development. This in no way excludes the possibility of planning on sound economic foundations. The two are interrelated and inseparable.

If the problem of land settlement constitutes only a relatively small item in national policy it nevertheless raises a principle which is fundamental in social development—are we or are we not to help the small man to realise and to maintain his independence? The answer we give to this question may be of great moment to the contentment of the countryside; to the welfare of the industry of agriculture; and to the evolution of a more sane and spacious way of life for the townsman.

A. C. RICHMOND.

LAND SETTLEMENT ASSOCIATION, LTD.,
43, CROMWELL ROAD, LONDON, S.W.7.

REPORT OF THE COMMITTEE ON FARM BUILDINGS

In November 1942 the Minister of Agriculture appointed a Committee to "consider and make recommendations regarding the layout, design and construction of farm buildings after the war." The appointed Committee included 2 Architects, 2 Land Agents, 3 Farmers, 2 Landowners and 1 Veterinary Surgeon, under the chairmanship first of Mr. Tristram Haward, Commissioner to the Duke of Northumberland, and subsequently of Sir Frank Engledow, Draper's Professor of Agriculture at Cambridge. The Report has now been issued. As might be expected, in view of the fact that all interests were fully represented on the Committee, the report deals in a most comprehensive manner with all aspects of the problem. The report is voluminous and from many points of view deals with the matter in the greatest detail; it is not possible therefore, nor is it desirable, for this review to be in any manner a synopsis. It appears to the writer that his main objective should be to draw attention to matters of particular importance, and to leave it to Landowners, Land Agents and others who may be faced with the problem of re-equipping their farms, to refer to the report for any detailed information which they require.

It may well be that to some the report is disappointing, as there is little in it that is new and indeed there are some points which can be criticised; no doubt others would describe the report as unimaginative. The fact remains, however, that, by contrast with buildings required for industrial purposes, little if any research has been, or is being, carried out in respect of agricultural buildings and, apart from a certain amount of work in connection with cowsheds, the Committee were of necessity bound to consider the whole problem *ab initio*.

It must be agreed that the task confronting the Committee was—although essentially interesting—an unenviable one, and it should be said that the report is a compendium upon all matters relating to the best current practice and is therefore the best possible foundation upon which to plan future investigational and research work. One of the main difficulties of the committee's task arises from the fact that the majority of our farm buildings were erected in a more leisurely age, when time and the economy of labour were of but little account. On the other hand, building costs were, generally speaking, relatively low and the very fact of the intrinsic permanence of many buildings makes them most expensive and difficult to reconstruct. Further, agriculture has been for the last decade passing into a period of change similar to that through which industry passed 100 years ago, and the Committee has naturally found it necessary to point out the difficulty of foreseeing the effect of future changes in technique and practice upon the functions of the homestead. Again, there appears to be little if any accurate knowledge concerning the housing of livestock or about the factors which affect comfort and health. On this and other matters which require research the Committee has made certain recommendations which it is hoped will result in a full range of critical experimental work being started in the near future.

The Committee, having realised the necessity of placing at the disposal of the industry the best technical advice available, makes a strong recommendation that farm buildings should come within the general scope of the National Advisory Service, and that a special branch should be set up to deal with this subject. They set out in considerable detail their views as to the manner in which this could best be achieved (paras. 82 to 92 inclusive).

The problems confronting the owners of agricultural property will require to be dealt with in two stages—firstly the immediate post-war period when the accumulated arrears of

ordinary maintenance will need to be made good and secondly the subsequent period when decisions will have to be made on questions of policy. It is in this latter period that the question will often arise whether to reconstruct and alter existing buildings or whether to "scrap the lot" and rebuild completely.

The report deals at some length with suggestions as to the lines upon which alterations and reconstruction may be carried out, but their recommendations are necessarily of limited application owing to the extraordinary diversity of the existing buildings and the great lack of uniformity of building practice throughout the countryside.

Upon one point, a matter of essential importance, the writer is bound to offer criticism —the matter of cost and general economics. Paragraph 12 states "the problem of finance is outside our terms of reference"; no doubt special instructions were obtained on this point, but on a matter of such prime importance it seems a curious omission; further since, on the matter of cost, the report is silent, questions may well be asked as to the extent to which costs were considered.

It is a matter of common knowledge amongst those dealing with the land that, as suggested in the report (para. 12) "Capital already invested in permanent farm equipment by a succession of owners bears little relation to the value of the holding, so that frequently the replacement value of the buildings exceeds the value in the open market of the land and buildings together." A point upon which all parties agree, whatever may be their position or their political convictions, is that if British agriculture is to survive the cost of its products must be reduced to the lowest reasonable level. There are two lines of approach to this problem, first by increasing the output per man and per acre, second by decreasing the cost per ton or per gallon of the products. An important item in the cost of production of any article is that represented by overhead charges, which include rent and interest on sunk capital. Reference to the reports of various Advisory Economists and others indicates that, while averaging probably 12% of the total cost of production, the figure represented by Overheads may be as high as 20%—clearly a heavy item when it is remembered that our products will sooner or later have to compete with those produced overseas under conditions that perhaps involve capital expenditure at an appreciably lower level. This matter seems to be of such primary importance that it seems desirable to examine in some detail the cost of the specimen layout recommended for a mixed farm of 250 acres (Chap. 7. para. 121). The farm for which the layout has been drawn up is a mixed farm with 20-25 cows in milk, implying total accommodation for fifty or sixty head of stock. The cattle and their followers are to be kept in covered yards with a milking shed nearby—a system of milk production which is recommended by many as being the most economical yet evolved. The buildings include a dairy, a milking shed and a fodder store with a granary. The accommodation for stock includes a range of 6 loose boxes, a bull box, a calf house, stabling for 2 horses and a loose box and 3 isolation boxes for sick animals. Other buildings comprise cart and implement sheds, a workshop, garage, staff mess room and office, together with a 6-bay Dutch Barn. An estimated cost of the layout amounts to about £11,000, and it must be pointed out that this figure does not cover the farmhouse, cottages, off-lying buildings, water supply or electrical installations. It is doubtful whether the cost of these latter items would be less than £4,500 implying a total expenditure of £15,500 for a farm of 250 acres, excluding the value of the bare land. It would not be unreasonable to suggest that the value of the land, without equipment of any description would be of the order of £10 per acre, which means that a total of £18,000 would be required to purchase and equip a farm of 250 acres, *i.e.*, £72 per acre. To many this may not seem a very high figure compared with the high prices at which farms have changed hands during the last year or two, but it must be pointed out that with interest and maintenance charges at 5%, the rental value would be £3 12s. 0d. per acre, and this upon a farm with land of ordinary quality valued in the

first instance at only £10 per acre. The report points out (para. 12) that facilities for cheap long-term finance are accorded to agriculture under the Agriculture (Miscellaneous Provisions) Act 1944. But even at the rate of $3\frac{1}{2}\%$ authorised in Section 2 and making no provision for maintenance, the rent would be as much as 50/- per acre. It is seen that, if the foregoing figures are correct, capital money must be available at a rate of interest not exceeding $2\frac{1}{2}\%$; even at that low figure the interest on capital would amount to as much as 36/- per acre. It follows that either the farm buildings of the future will have to be constructed on the cheapest possible system, with materials of really low cost, or that capital must be made available to the industry at an extremely low rate of interest. The tax relief granted under Section 33 of the 1945 Finance Act is indeed bound to be of the very greatest assistance to the industry, and is to be welcomed by all. The ability to recover tax upon the capital cost of farmhouses, cottages and buildings over a period of 10 years should certainly encourage many landowners, more especially the owners of large estates, to expend money on their properties; but, as the Committee is at some pains to point out, it is unlikely that there will be many farms requiring a complete new set of farm buildings; such replacement would be uneconomic and impracticable. The problem will rather be one of steady replacement of out-worn or entirely unsuitable buildings, and the adaptation of others to satisfy modern requirements.

When the economics of the industry are being considered, it is clear that the capital invested may be conveniently divided into two parts—the capital sunk in land and its permanent equipment, and the floating capital invested in crops, stock and movable equipment. The essential difference between these two types of capital is that, whereas the former is realisable only on the sale of the land itself—and realisation of a part involves the realisation of the whole—the liquidation of the floating capital does not necessarily involve the sale of the land, and any separate part may be cashed as an individual item. It can be probably said of capital that, within reasonable limits and for any given sum, the less that is sunk and the more that is invested in floating assets the greater is likely to be the efficiency of the enterprise. This particular point, which is acknowledged to be debatable, naturally affects the whole outlook upon permanent farm buildings. A further point arises also in connection with livestock and grassland research. During the past 20 years great changes have taken place in stock farming, and it is necessary only to mention the introduction of the Milking Bail, and of the folding units now in use in the pig and egg-production side of the industry, to say nothing of the views on horse keeping expressed in the report. It is impossible to estimate the extent to which these open-air systems will become general practice in another decade, but it must be pointed out that these systems require the minimum of sunk capital. It must be remembered that in New Zealand, where the climate is on the whole comparable with ours, the money invested in permanent buildings is small, and ways and means of stock husbandry have been evolved (*i.e.*, the rugging of cattle and horses) with which the New Zealand farmers are entirely satisfied. It is believed that both health and production have improved under this open-air system. Further, as these Islands are blessed with a climate which, on the whole, is pre-eminently suited to growing grass, and as this crop is generally regarded as being the best and cheapest food for stock, it is reasonable to suppose that the farmers of this country will turn their attention more and more to livestock products. As plant breeding and research in grassland management gain in impetus the production of herbage per acre will tend not only to rise in the summer but also to extend further into what is now regarded as the dormant period. If these assumptions are correct it follows that the chief point to which attention must be directed in the planning of homesteads is provision for the consumption by stock of an increased and extended growth of herbage, both in its natural and conserved state, by grazing and by the consumption of hay, dried grass and silage, with provision for the storage of the conserved products.

* * * * *

In its approach to its problem the Committee has drawn up (para. 15) a most valuable set of "Rules of Good Planning" of which the more important are :—

(*a*) Appropriate Cost.
(*b*) Adaptability.
(*c*) Standardisation.
(*d*) Economy of Maintenance.
(*e*) Convenience of Layout.
(*f*) Insurance of Animal Health.
(*g*) Appearance.
(*h*) Comfort and economy of labour.

These rules are as a whole self-explanatory, although the importance of several of them is such that explicit comment is necessary here.

By the term 'appropriate cost' the Committee lays down the axiom that capital should only be invested where necessary, to maintain or raise the level of profitable production. This requirement leads logically to the dictum that, as far as possible, buildings should be planned in such a way that they may be adapted for many different uses. Many Landlords will recall with regret the expense to which they may have been put in the past in erecting, at the express wish of a tenant, a building designed for some specific purpose, equipped with the latest fittings which, on a change of tenancy, has become wholly redundant owing to a change of farming practice. Few things are more disheartening to a Landlord who is keen on the proper maintenance of his estate. There is nothing which militates more against good relationship between Landlord and Tenant than a change of policy on the part of the latter which, in this particular manner, sterilises an investment of the former. The Committee, therefore, stresses the utmost importance of designing buildings in such a way that by changes of internal fittings they can be adapted to a variety of purposes.

The report deals at some length with the question of adaptability (paras. 32-43) and shows how this requirement has been dealt with in a limited degree on the continent and in North America, by the erection of a single comprehensive multi-purpose building ; in some cases with only one floor but more particularly in North America, with two or even three stories. The Committee points out, however, that the climate is an important factor in the evolution of the latter type, and whilst not condemning it in its application to English agriculture, they point out that investigations into the use of this type of building over here are necessary before any recommendation can be made.

There is obviously some difficulty in arriving at any very definite recommendations for the manufacture of prefabricated buildings, although, within the limits imposed by the problem, the Committee has made certain proposals. They suggest that buildings 16 ft. in width are suitable for housing almost any type of livestock, and that buildings of 35 ft. in width are similarly suitable for almost all other purposes—granaries, fertilizer stores, implement sheds and so forth. In both types of building the Committee recommends a standard height of 8 ft. to the wall plate and a standard length of unit—*i.e.* distance between roof trusses—of 12 ft. They believe that in most cases the requirements would be met by the mass production of standard framed buildings of the following three spans :—16 ft., 21 ft., 35 ft. The method of prefabrication, and indeed the materials to be used, are clearly matters for further investigation. As is pointed out, the best example of the prefabricated building in agricultural use today is the Dutch Barn, which on many farms has been satisfactorily incorporated into the general layout of the homestead. The steel-framed Dutch Barn is, in all probability, likely to be regarded by many as the most suitable foundation upon which to build, having in mind its eminent suitability for adaptation. The normal barn is built with the supporting members 15 ft. apart; if these were erected at 12 ft. centres with floor plates at ground level the fixing of intermediate uprights for the support of the

prefabricated reinforced concrete slabs, windows, door jambs, etc. would be a simple matter, and possible for the ordinary farmer to carry out himself. Again, steel is probably the best material of all for the fixing of brackets for the provision of internal fittings.

Under the heading ' convenience of layout ' the report draws attention (paras. 100-118) to the need for the Planner to bear in mind that nearly all traffic on the farm begins, ends at, or passes through the farmstead. This traffic may be conveniently divided into four main groups, as follows :—

1. The entry and exit of animals.
2. The delivery and distribution of Feeding stuffs, fertilizers and other stores.
3. The despatch of Milk.
4. The collection and distribution of Farmyard Manure.

The recommendations made in the report (paras. 100-118) are most valuable and should be studied in detail by all interested, whether they regard their own layout as perfect or not. There is no need, nor is there space in this review, to particularise the recommendations ; suffice it to say that the general conclusion reached by the Committee is that " the farmstead should be laid out on the basis of a through main farm road from which a loop road should run, rejoining it on the other side of the farmstead. Stock buildings and yards would be grouped on the island enclosed by these roads."

Much has been said as to the necessity for improving the *living* conditions of the agricultural worker, and it is generally agreed today that the main factor limiting an increase in production is the shortage of skilled labour. The report stresses the need for the realisation by the farming community that if the younger generation of farm workers are to be persuaded to stay on the land, it is essential that their *working* conditions should be improved so that they may be as nearly comparable as possible to those of the factory workers. They underline the need for such things as firm and dry communications between the different parts of a farmstead, good lighting (both natural and artificial) easy loading levels, the provision of a mess room and drying room, with adequate lavatory accommodation.

By ' economy of labour ' the Committee means the achievement of a higher output per man, and the report deals at some length with the possibilities of gaining this most essential end by thoughtfulness in the initial planning of a farmstead. However, on the matter of easy loading it appears that the Committee has not laid sufficient emphasis on the need for level loading and unloading ; indeed the suggested design of both the granary and the fertilizer store may be criticised from this point of view. Nothing is more annoying or time-wasting to a farmer than to find, in the middle of a busy day's threshing, that he has to curtail his output in order to send a man to the granary to help unload. It seems strange that the Committee should still advocate the use of hoists which inevitably involve the employment of two or sometimes three men to work them, when great saving of labour can be accomplished by the use of appropriate loading ramps, either up or down in relation to the ground level, to both floors. Level loading and unloading is then possible on and off the vehicle by means of a sack barrow. By careful thought in the design of a building of this description it is quite possible at no great expense, for heavy loads to be moved without once lifting by hand. Indeed this can be one of the most important aids to economy of labour which careful planning may achieve. The ideal arrangement enables the threshed stock-feed grain and purchased cake and grain to be stored on the first floor, fed by gravity by a hopper to a mill on the ground floor, and blown either by the cyclone of a Hammer Mill, or by a separate cyclone, to the first floor once more for sacking off. The ground floor need not be more than 6 ft. 6 in. from floor to ceiling joist, and further the remainder of the space on the ground floor—apart from that taken by the Mill—can be conveniently used for the storage of such things as Binder Twine, Artificial Manures, small tools and implements.

The main body of the report (from para. 136 inwards) deals with recommendations in connection with specific buildings, and the following is an attempt to select items which appear to be of particular interest and importance.

THE BARN (paras. 136-153).

Somewhat naturally the first building to be considered is the Granary or main storage building, and the subject is dealt with at some length. It may probably be said that on practically any farm in any district, and whatever may be the system of farming involved, storage accommodation will be required, and it follows that the need for adaptability is probably less in the case of the Barn than in that of any other building. The main points to be aimed at are that the building should be sufficiently substantial to keep stores dry and in good condition and that it be well ventilated and vermin proof. It should also be strong enough to withstand the stresses and strains of power-driven machinery on both the ground and the first floors.

In addition to the criticism mentioned above under the heading 'economy of labour' the writer feels it necessary to point out that the bins required for storage of home-grown feeding-stuffs could be improved upon. Those recommended by the Committee are of the ordinary type, well known to farmers, with vertical removable side boards. This type necessitates all but the driest grain in dry weather conditions being periodically turned in order to avoid mould, a procedure that involves unnecessary labour. An arrangement which from nearly every point of view is preferable entails the side boards being fitted at an angle of 45° to the horizontal in reversed louvre fashion. This type of bin has two advantages, firstly it enables the grain at the bottom of the bin to be used first, by the simple removal of the bottom board, and further it enables the grain to retain its condition longer by allowing free ventilation.

ACCOMMODATION FOR MILKING COWS (paras. 154-284).

This section will be to many the most important part of the whole report and, somewhat naturally, the Committee has given the very fullest consideration to this matter. There are, of necessity, difficulties in the way of any clear and decisive recommendations in view of the changes which are taking place, and which are likely to take place in the future, in systems of cow-keeping. The three main systems in use today are specified as follows :—

1. The cow house system in which the cows are housed and milked in the same building.
2. The milking house system in which the cows are housed in covered or partly covered yards or other available buildings, but are milked in batches in a special milking house adjoining the dairy.
3. The open air system in which no housing is provided, the cows living in the open, being milked by machine in a movable bail.

Each system quite obviously has its own advocates but, as the Committee points out, owing to the great variation in both soil and climate a system suitable for one particular farm need not be as suitable for another.

The cowhouse has the drawback that it is a specialised single-purpose building. The degree to which this criticism can be overcome depends very largely on the extent to which the building trade can manufacture a building in which the internal fittings can be erected or removed without great expense. The siting of the cowshed will be clearly governed by the general layout of the farm buildings. It is necessary to consider easy approach to the roadway and to pastures, and convenient access to the dairy and food stores. Important features of cowhouse planning are wide, clean and dry approaches for the cows and a free passage for the milk, well removed from all sources of contamination. For the safety and comfort of the cows it is desirable that there should be sufficient floor space to allow free movement in to and out of the building, and to permit the cows to be milked and to rest in

comfort. The minimum allowance of 50 sq. ft. of floor area per cow is recommended as necessary to ensure comfortable conditions for both cows and staff. Fresh air and good ventilation are essential, a condition which it is possible to achieve only by ensuring a continuous circulation and renewal of air in the cowshed by providing foul outlets in the roof and fresh air inlets at lower levels.

Lighting is of primary importance particularly at the hind quarters of the cows and, as the Committee point out, roof lighting is more effective and economical than wall lighting—a point which many agricultural architects seem to forget.

Sliding doors are, generally speaking, more servicable than those hung on hinges because sooner or later the latter will suffer damage by the wind or from an excited animal.

On the subject of ventilation the Committee remarks that research is needed before definite recommendations can be made as to the best methods. They make it clear, however, that the roof is the point at which provision should be made for outlet ventilation, provided that the ridge is not too high, and that provision should be made for an inlet of fresh air at a level below that of the cows' heads. On the matter of ventilation it may be said that controllable air movement is of greater importance than mere air space, and it is satisfactory to note that this fact is appreciated in the current Milk & Dairies Order.

As to lighting the Committee recommends that at least three square feet of roof light per cow is necessary with a single range house, and rather more in a double range house. If wall lighting is provided it recommends the minimum of four square feet. Artificial light should be provided wherever the services exist, and though the report does not mention the desirability of the lighting points being low down, the writer has found that lights of the ship's bulkhead type, fixed 2 ft. 6 in. from the ground, are preferable to any other type.

As a rough guide to water requirements, a useful figure to be recommended is that a daily supply of about 30 gallons per cow is desirable to enable all needs to be met.

It seems desirable to mention a point of possible improvement to the design of the cowshed. A difficulty frequently experienced is that cows will insist on standing with their hind legs in the dung channel, a fact which makes them unnecessarily difficult to clean. This difficulty can, to a considerable extent, be overcome by so forming the channel that the edge nearest the cows has a slope of 45° to the vertical; this gives the cows a feeling of insecurity and ensures that they stand on the standing provided.

The Committee stresses the need for the preservation of the liquid manure for subsequent use on the land. Provision should be made for easy handling of the manure daily, and by careful planning it is possible to economise labour by arranging either overhead carriers or, where the width of the gangway allows, the use of a small dung cart.

As for the recommendation of cowsheds as a whole, there is nothing new or out of line with the practice of the day. The report however emphasises the fundamental points to which the Committee feels it essential to draw attention.

On the milking house system the Committee's observations are fully elaborated, and all those interested should read the paragraphs relating to this and the other systems of cow keeping. The chief advantage attaching to this system is that specialised buildings are reduced to a minimum and the building costs are lower compared with those of the cow house system. Among other advantages claimed are that the cows are better in health, that milk of higher quality can be produced with less labour and trouble, that labour is saved by cutting out the daily cleansing of a large cow house, and that manurial losses are greatly reduced. Against these advantages must be set the alleged disadvantages which resolve themselves into the following points, *viz.*, the difficulty of isolation for disease control, the danger of bullying by "master" cows, and the difficulty of controlling individual rations. The planning of new buildings for milk production under this system, or, by the

alteration of existing buildings, needs very careful attention in order to make the most of the system and avoid ' traffic blocks.'

The Committee recommends that not more than ten to fifteen cows should be yarded together, and suggests that an area of 100 sq. ft. per cow is desirable for the smaller and about 150 sq. ft. for the larger breeds. They emphasise the need for really careful attention to the feeding of the concentrates, particularly in the case of the heavy-yielding cow. As a guide they suggest that the average cow will take two minutes to consume one pound of concentrates, and it is necessary, in order to maintain milk yields, that this fact be fully appreciated. So far as the bulky portion of the ration is concerned, this is generally fed in the fields or in the yards housing the cows. Under this system it is sometimes difficult to ration this part of the animal's diet, although in practice it is generally recommended that animals be grouped in yards according to their yields. It is thus possible to ensure that the bulk ration of each group is adequate. If, again, the design of the yard follows the general layout of the Scottish ' court ' with a feeding passage along two or three sides raised above the general floor level of the yard, bulky food may also be rationed by tying the animals at feeding time with a simple form of yoke.

The most useful and perhaps the most economical variation of this method is that which involves a " marriage " between the milking-house system and the open-air system. During the five or six months of summer the cows are milked in the fields in a movable bail of standard type and the bail is then moved to a pre-arranged concrete standing planned at some convenient point near to the yard which will become the cows' winter quarters. During these winter months the system is to all intents and purposes similar to that already described as the milking shed system. It is, however, thought desirable that, when this or the purely open air system is employed, some part of the buildings should be equipped as a permanent dairy, because, generally speaking, the milk-cooling and sterilising section of the movable bail is not in every way satisfactory. This marriage of the two systems has the additional advantages :—

1. That a minimum of capital is sunk in specialised buildings and that the bail as such, being the tenant's property, can be cashed at any time if the farming plans should involve a departure from milk production.
2. That it combines the merits of both systems, ensuring a minimum loss of manurial value and requires the minimum of labour.
3. That it enables the farmer to make use of a breed which would not be suitable for whole-time open-air dairying. Furthermore it enables a tenant of land unsuitable for open-air dairying in the winter months to make use of the system during the period of the year when conditions are suitable.

The open-air system is fully dealt with in all its aspects in a publication of the Agricultural Economics Research Institute, Oxford (Open air Dairy Farming—by R. N. Dixey), and the Committee has not thought it necessary to consider this at any length. They underline the determining factor, namely, the provision of an adequate field water supply. They emphasise, too, that in general the system is suitable in districts of a mild climate with low or medium rainfall and with light and well-drained soils. Under these conditions the system leads to economy of labour and it solves entirely the problem of manure disposal.

On the matter of accommodation for calves the Committee necessarily points out that the desirable type of building will depend upon the system adopted. They state it to be generally considered that calves should be kept in separate single pens until they are three months old, and then in groups of three to six for the next two or three months. In view of the increasing importance of all-the-year-round milk production, involving a high proportion of autumn calvers, the Committee points out that, for large and medium herds rearing as many as possible of their own replacements, special building provision should be

made and that, for small herds, loose boxes properly fitted and equipped will be adequate. They mention a most interesting system followed in New Zealand whereby calves are kept in age groups except at feeding time, when they are separated. By this means the habit of navel-sucking is entirely avoided. They suggest that the possibilities of this system of management should receive full technical investigation. Buildings forming the calf-rearing unit are very fully discussed in the report. On one particular point it seems desirable to offer criticism : the Committee suggests the desirability of fitting automatic drinking bowls for the use of calves. Many farmers will, no doubt, criticise this recommendation in view of the desirability of rationing the calves' consumption of cold water. Secondly, and probably a minor point, is that, so far as the writer's experience goes, there are no drinking bowls on the market which a calf is able to operate, since the spring used to retain the valve in a shut-off position is almost invariably too strong to allow it to be worked by a calf.

ACCOMMODATION FOR THE BULL.

As the report most rightly states, the accommodation for the bull is very unsatisfactory on many farms—one might almost go so far as to say on most farms. It is undoubtedly because of the dark and cramped quarters in which so many bulls are housed that they get an early reputation for ill temper. The ideal arrangement for keeping a stock bull is a good-sized loose box with direct access to a small paddock. Where this is not possible the bull should have at least a small exercising yard adjoining his box, and the yard should have an open view in order to accustom the animal to the presence of human beings, and other animals. Further it is essential that the box and yard should have a concrete floor to enable the bull's feet to be kept in good order. It is important, whatever system may be adopted, to arrange matters so that the bull may be fed and watered from outside the pen.

STABLING FOR THE FARM HORSES.

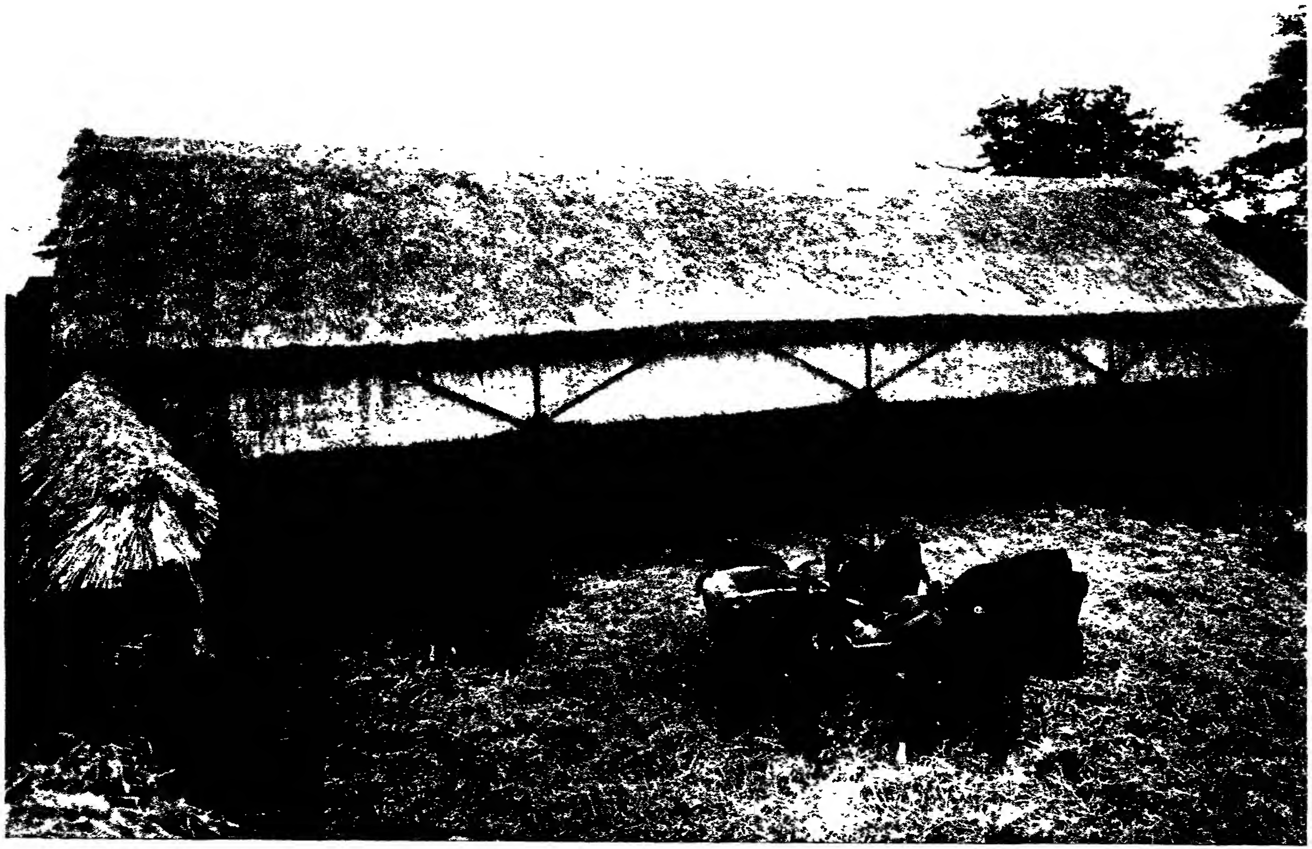
As to the generally accepted system whereby farm horses are kept in buildings specifically designed for that purpose the Committee is at some pains to point out that experience has proved that under certain conditions this system is by no means the best. They instance the case of a farmer " whose widespread fame for successful farming is matched by his reputation for judgment and allround ability with horses " who states that, in his experience, no housing of any type is necessary, since all his horses had lived out-of-doors for the last fifteen years. Let it be said at once, however, that the report mentions neither the class of soil nor the location of the farm, and it must not, therefore, be inferred that this particular system is likely to be suitable throughout the whole of these islands. On the other hand there is no doubt that a very great deal of money has, in the past, been wastefully spent on housing this class of farm stock in specialised buildings which are, in general, difficult and expensive to adapt for any other purpose. The two alternatives to complete outdoor stabling are (*a*) an open yard with shelter and (*b*) fully enclosed stabling. As to the former, those who follow this system are satisfied that the horses enjoy better health, and that there is a saving of labour in keeping them in this manner. In districts in which stabling is essential, the report recommends that stables should be single-storey buildings with a pitched roof, *i.e.* without a loft. Apart from the obvious warning that the buildings should be of substantial construction, nothing new appears in the report.

HOUSING OF PIGS.

It will be well known that no class of farm stock has been more subject to the vicissitudes of fortune than the pig, and that in no branch of the industry has more money been lost. Rightly the Committee sound a note of warning against the equipping of a 250 acre mixed farm with any specialised type of permanent building for pigs. They point out that on a

TUBULAR FRAME BUILDING IN COURSE OF ERECTION, SHOWING DETAILS OF CONSTRUCTION.

Photos. by Courier Press, Leamington Spa.



COMPLETED BUILDING, SHOWING THATCHED ROOF AND THATCHED CAPPING TO SIDE WALLS.

farm of this description the type of building most suitable is that which would normally be described as a tenant's fixture, particularly as farrowing crates are now widely used. They emphasise, too, that where ample straw is available the fattening of pigs in well-sheltered yards has been found, in suitable localities, to give excellent results. This system ensures a saving both of labour and of manurial value. Very useful details are given of a simple farrowing hut which may be used an an alternative to the farrowing crate.

The report deals at some length with a specialised building designed for indoor pig keeping, and the attention of those interested in this subject is directed to paras. 318 to 334 inclusive. The report recommends that further technical investigation is required into this specialised side of the industry.

LOOSE BOXES (paras. 337 to 356).

As the Committee points out, loose boxes " serve so many purposes that they are one of the most useful buildings on the farm. They can be used for calving, foaling and farrowing ; for the rearing of young stock, including pigs ; for the examination and treatment of all kinds of beasts needing attention ; and, when not required for stock, for storage, or even in place of a chaff house." This statement indicates the great importance of loose boxes, and there is little need to say more as to their value. Comprehensive details are given of recommended designs and types of construction.

STOCK YARDS (paras. 357 to 384).

The report deals in some detail with the subject of yards, dividing them into three types (*a*) the open yard with minimum shelter, (*b*) the partially covered yard and (*c*) the wholly covered yard. From every point of view it may be said that yards of one description or another are probably as useful as any kind of livestock accommodation. It must be pointed out, however, that the availability of a constant supply of straw is essential. The Committee makes the obvious point that it is a characteristic of the British farm that the layout of main buildings is generally such as to give one or more sheltered enclosures which, completed by a fence, will constitute a useful yard. It is not essential for yards to be enclosed by walls or by clad fencing on more than two sides, provided only that these are the North and East. So far as the flooring material is concerned, either hardcore or concrete is essential, though in the writer's experience concrete is quite unnecessary in the case of covered yards, provided an adequate covering of hardcore is laid.

As for drainage, there will ideally be none from the yard as all moisture should be absorbed by the straw. Where, however, the soil is heavy, or the rainfall requires it, drainage should be provided in the ordinary manner. The report mentions an interesting type of covered yard, roofed on the " saw-tooth " system, which has much to recommend it on the score of cheapness.

Of yards in general the Committee makes the very important point that the roof supports, whether the yard be partially or wholly covered, should be sited and spaced in such a way as to facilitate ' mucking out.' They very rightly point out that developments in the mechanical clearing of muck are now taking place, and emphasise the need for facilitating this laborious operation. They recommend that the side or sides which are fenced should be constructed in such a way that at least some sections are easily removable. As an alternative to the yard as a landlord's fixture—a permanent construction to whatever extent it may be covered—the use of straw yards has been widely exploited during the last few years. Straw ' crew ' yards have been in use in the Eastern counties for many years, and farmers in that part of England have found them entirely satisfactory. There

are, naturally, limitations in the use to which straw buildings can be put, and the following general points should be borne in mind :—

1. *The risk of fire.* This risk is, generally speaking, rather more apparent than real. Animals are more likely to be housed in buildings of this description in the winter months when the risk of fire is at a minimum. Provided that the walls are not too high, and that the covered portion is not too large a proportion of the whole, the risk is not considered to be very great.
2. *Fleas* and other similar types of vermin are obviously likely to be more troublesome in a straw yard than in any other type of building.
3. *Drainage* is an important consideration owing to the difficulty of providing any form of eaves guttering where the roof is thatched.

Bearing these general considerations in mind, straw buildings are obviously suitable for housing horses, store and feeding cattle and pigs, and for the protection of implements and tractors. Several types of construction are fully dealt with in the report, although probably the most promising type of all had not been evolved when the report was published. This type involves the use of tubular scaffolding, large quantities of which may become available in the near future. The main difficulty in the construction of a straw building lies in the formation of the roof, as its length and pitch are dictated by the length and diameter of the timber available. The availability of tubular scaffolding puts an entirely different complexion on the matter, as the overall dimensions of the roof when so supported, are practically unlimited. Further, the strengthening and protection of the side walls against the stock is a relatively easy matter. This form of construction has the additional merit that the only expendable material is the straw, and the skeleton of the building may be added to or, indeed, moved to any other part of the farm as circumstances require. Photographs are shown of this type, both in course of erection and completed, which may be of general interest.

* * * * *

The report deals with many other buildings including Dutch Barns, Silos, Storage buildings for grain and fertilizers, Tractor and Implement Sheds and workshops, and an immense amount of useful information is given in connection with their design and construction.

An interesting chapter (paras. 454-470) deals with buildings suitable for the small farm, and the writer would like to draw particular attention to the layout illustrated by "D" and "E" on page 175. This is recommended as being particularly suitable to Northern counties, but the plan has much to commend it for any district.

There are useful chapters concerned with the control of vermin and rodents, and with fire prevention, together with a complete chapter on electrical installation.

It is well nigh impossible in a short article such as this to do justice to a report running to more than 200 pages, and if the writer should have succeeded in whetting the appetite and arousing the interest of those concerned with farm buildings so far as to induce a careful study of this report, he will feel amply repaid.

N. E. B. ELGAR.

Warwickshire War Agricultural Executive Committee,
6, Guy's Cliffe Avenue,
Leamington Spa.

RECENT DEVELOPMENTS IN CHEMICAL METHODS FOR THE SELECTIVE CONTROL OF WEEDS

THROUGH the centuries, the methods employed to deal with weeds have remained basically unchanged. With the plough the weeds could be buried while in the growing crop weed suppression was dependent on the hand, the hoe and the harrow. It is fifty years ago that there was a really novel development. In 1896 Bonnet showed for the first time that by spraying a growing cereal crop with dilute solutions of certain chemicals it was possible to kill annual weeds but without killing the crop. Subsequently to those first experiments progress in this new field was surprisingly slow. On account of its low cost and non-corrosive properties copper sulphate was the material which was most widely employed for spraying cereals. Other substances to gain some but not widespread popularity were ferrous sulphate, sodium nitrate, ammonium sulphate and, as powders, Kainit and cyanamide. All of these materials suffered from the disadvantages that they were effective against only a few of the common weeds of arable land, and in addition, were limited in their effectiveness by weather conditions. All of the materials were slow acting and demanded at least 24 to 48 hours of fine weather after spraying.

For over a decade sulphuric acid remained out of favour. There were no doubt three contributory causes. The corrosive properties of sulphuric acid were well known, there was the difficulty of handling and spraying in the field and it was not realized that the apparent damage to the cereals, immediately after spraying, did not necessarily lead to a depression in final yield. It was left for Rabaté (Ref. 1) to demonstrate in 1911 the real worth of sulphuric acid for weed destruction in cereal crops. The great advantage of sulphuric acid is that it acts quickly and so only needs a few hours of fine weather. Moreover, Rabaté demonstrated that it was effective against a wide range of annual weeds and, what is more, showed that crop yields were, in consequence of spraying, materially increased.

The immediate application of these findings to farm practice were at first restricted to France. Special lead-lined sprayers were developed and tens of thousands of acres treated each season. Subsequently sulphuric acid was compared with other selective herbicides by Korsmo (Ref. 2), in Scandinavia and by Blackman and Templeman (Refs. 3 and 4) in England.

Korsmo found that by spraying cereals with either ferrous sulphate, sulphuric acid or nitric acid, or by dusting with cyanamide, the increase in yield due to weed suppression averaged, for Norwegian conditions, no less than 25 per cent. In England, increases up to 227 per cent., following on weed control with sulphuric acid, were recorded for cereal crops by Blackman and Templeman. The latter also showed (Ref. 5) that the gain in yield was dependent on the kind of annual weed and its density, and on the season. With weeds like yellow charlock (*Brassica arvensis*) competition with the crop is largely for nitrogen. But with taller and more aggressive weeds such as white charlock or wild radish (*Raphanus raphanistrum*) competition may be for both nitrogen and light. Competition, too, is greatest in the early stages of cereal development, and it follows that leaving spraying until the weeds are in flower is bad practice, since by then the harm has been done. Besides, with sulphuric acid the most effective control is obtained by spraying when the weeds are in the seedling stage.

In spite of the great value of sulphuric acid for weed control, there remained the grave drawback of corrosion and the need for careful handling in the field. So the search for

alternative substances went on. Blackman and Templeman tried acid salts such as sodium hydrogen sulphate and ammonium hydrogen sulphate, but these were not, on the whole, a success. In the meantime, Bissey and Butler (Ref. 6) had shown in the United States that for wild mustard (*Brassica arvensis*) copper nitrate at 1.0 per cent. was the equal of copper sulphate at 5.0 per cent., and copper nitrate spraying was advocated in Germany (Ref. 7, page 101). Nevertheless a comprehensive survey of the relative merits of different copper compounds was still lacking at the beginning of this war.

The next step forward occurred when Truffaut and Pastac in 1932 filed a patent in France for the employment of yellow dye stuffs, such as dinitro-ortho-cresol and dinitro-ortho-phenol, for selective weed control in cereals and other crops. Subsequently, in France and then in America, a paste of the sodium salt of dinitro-ortho-cresol was put on the market. This paste had the advantage that it was not corrosive either to clothing or metals, -- but being a dye stuff, stained skin and clothing.

In France, many claims were made for the weed-killing properties of this new material but the claims were seldom backed with critical data. In America the claims were on a much more substantial basis and foremost in the developmental work were workers in California, especially Westgate and Raynor (Ref. 8). Their investigations showed that such weeds as those mentioned above could be readily controlled in cereal crops by spraying with the sodium salt of dinitro-ortho-cresol* at concentrations of 0.3 to 0.6 per cent.

This spraying treatment did, however, give variable results and the idea was put forward that this variability was related to the temperature conditions at the time of spraying (Ref. 8). Below a temperature of 50 °F the sodium salt was slow acting, and by no means as effective as when the weather was warm—that is well above 50 °F. But the influence of temperature, it was found, could be minimized if ammonium sulphate was added to "activate" the sodium salt. This "activation" moreover brought about a more efficient control of annual weeds.

When in 1941 the present series of investigations on the general problem of weed control were started under grants from the Ministry of Agriculture and the Agricultural Research Council, it was clear that there were three immediate main lines of investigation. Could the use of sulphuric acid for weed destruction be extended to other than cereal crops ? To what extent would the DNOC compounds replace sulphuric acid ? What were the relative efficiencies of different copper salts for selective weed control ?

In considering the extension of sulphuric acid spraying the principles underlying the selective action in cereal crops had to be taken into account. Aslander (Ref. 10) had observed that this selectivity was dependent on morphological differences between the weeds and the crop. Cereals have more or less upright leaves, so the spray droplets tend to run off the plant ; the surfaces of the leaves are waxy and so the spray does not readily penetrate ; and, above all, the "growing point" of the cereal is basal and is protected from the spray by the leaf sheaths. Fortunately many annual weeds are in a different category. They possess apical and unprotected growing points and flat leaves which catch the spray. Most of them lack a waxy surface layer though a few, like corn marigold (*Chrysanthemum segetum*), are waxy and are therefore more or less resistant. This resistance can in part be overcome by adding a wetting agent to the spray.

Control of Weeds in Onions.

These differences in structure and habit between cereals and the commoner annual weeds are roughly the differences between monocotyledons and dicotyledons and, apart from the grasses, few English crops are monocotyledons. Amongst the few are onions and leeks and these, on the basis of their habit of growth, seemed likely to resist sulphuric acid.

*For the sake of brevity dinitro-ortho-cresol will be referred to as DNOC in the rest of this paper.

Moreover, it was well established that onions are peculiarly susceptible to weed competition and hitherto they had demanded much time and labour for hand weeding. Finally this need for hand weeding was in 1941 a potential bottleneck in the plan for an increased acreage of home-grown onions to offset the loss of peacetime imports.

During 1941 some fourteen experiments at once showed the practicability of destroying annual weeds in onion crops with sulphuric acid. In fact, the onion proved to be even more resistant to sulphuric acid than the cereals—as long as spraying did not take place until the onion seedlings had "straightened out" and had reached the two-leaf stage. Further research demonstrated that it was possible to spray the onions a second time when there was a second germination of weeds to cope with in late May or June, by which time the onions usually possessed four to six leaves. Taking the results as a whole, over the four seasons from 1941 to 1944, the average yield from twelve experiments of hand-weeded unsprayed plots was 9.2 tons per acre; with the single spraying the yield was about the same (9.4 tons) while with the double spraying there was a small reduction—8.4 tons per acre. In all the experiments the only *marked* check or depression in yield due to spraying was in those crops where spraying did not take place until the weeds were higher than the crop. Here the weeds, by shading the crop, made the onion leaves more tender and therefore less resistant to the acid spray.

Allowing the weeds to get somewhat out of hand before spraying, besides leading to crop damage, also leads to a smaller degree of kill. Annual weeds like shepherd's purse (*Capsella Bursa-Pastoris*) knotgrass (*Polygonum aviculare*) and annual nettle (*Urtica urens*) become, with age, more resistant to spraying while others like goosegrass (*Galium aparine*) do not. Some weeds, too, especially when they have passed the seedling stage, are better controlled if a wetting agent is added to the spray—fat hen (*Chenopodium album*) for example. But this greater wetting power of the spray is also liable to cause a greater penetration of the spray into the onion leaves. If the crop is growing well this extra check is immaterial, and loss in yield has been observed only on light soils in dry springs. For example over the four years the addition of a wetting agent only depressed the yield in 3 out of 17 trials.

Although sulphuric acid had proved so successful in the initial onion experiments, it was realized that there was still the drawback of corrosion and the difficulty of handling. So a search was continued, at the same time, for alternatives more easy to handle. In this connection, during earlier work on sodium chlorate, it had been found that the wild onion was highly resistant. It seemed therefore possible that this resistance was shared by the cultivated onion. If this were so then the onion should stand up to 1-2 per cent. concentrations of sodium chlorate which were found by Clouston and Hill (Ref. 11) to kill some annual weeds. Unfortunately these concentrations were not effective against many of the weeds which are common in onion fields.

The sodium and ammonium salts of DNOC were also tried, but proved to be even less useful since they were partially toxic to the onion at all stages of its growth. In fact, on occasion, onions in the young two-leaf stage were killed outright—a result incidentally quite contrary to the findings of Westgate and Raynor in America.

Other herbicides investigated were copper chloride and several emulsions of various tar-oil fractions. They, in turn, all suffered from the drawback that while they did not check the onion growth unduly, they killed only a few of the weeds and did not compare in efficiency with sulphuric acid.

Pre-emergence Spraying of the Seed Bed.

In the course of the first year's experiments it was observed that many annual weeds appeared above ground before the crop. In consequence, by the time the onions were fit

to spray, *i.e.*, when they had reached the two-leaf stage—these earlier germinating weeds, because of their size, were less readily controllable by spraying. It seemed apparent that a more effective control could be achieved if an additional spraying could be timed to take place when the weeds had germinated but the crop seedlings were still just below ground. Tests, first on an experimental scale and then on a field scale, proved that this "pre-emergence" technique of spraying was a practical proposition. The onion seedlings were in no way damaged as long as the initial shoots were *below the soil surface.* The only damage occurred where the wheel tracks of the tractor and sprayer happened to follow directly on top of the onion rows. This packed the soil, and depressed the final stand of seedlings.

Such damage can, however, be overcome by adding a small proportion of quicker-germinating radish seed to the onion seed at the time of drilling. The radish seedlings, which germinate with the weeds, serve to mark the rows so that it is possible with a properly adjusted track to keep clear of the rows while spraying up and down them. The radishes are killed by the spray and the onions emerge in a clean seed bed.

This pre-emergence spraying can be applied to any crop where the weeds normally germinate in advance of the crop. Its value is most apparent in spring-sown crops which are slow to germinate—*i.e.* onions, carrots, parsnips, round beetroot and parsley. There are, however, occasions when the spraying is possible for root crops such as mangolds and sugar beet.

No effective substitutes for sulphuric acid have yet been evolved for this new technique. Sulphuric acid has the advantage that, once the spray droplets reach the soil surface, the acid combines with the soil bases to form innocuous salts– for example insoluble calcium sulphate. Other materials such as DNOC compounds or tar oils leave spray residues which may injure the emerging seedlings or, in some instances, kill them completely.

Control of Weeds in Cereal Crops.

Whereas for pre-emergence spraying and weed control in onions sulphuric has proved to have most merit, in the eradication of weeds from cereal crops the premier position of sulphuric has now been lost. Here investigations have developed along three main lines. Two have already been mentioned—those comparing the effectiveness of various copper salts, and those on the performance of DNOC compounds under English conditions. The third is an entirely novel development—the evolution of selectively toxic growth-promoting substances.

This new approach to differential weed control arose out of the investigations of Slade, Templeman and Sexton (Ref. 12) on the effects of growth-promoting substances on the development of cereals. In pot culture experiments, carried out in 1940, they noted that spraying with growth-promoting substances, such as the well known alpha-napthyl-acetic acid, killed weeds like yellow charlock but did not harm the cereal. The importance of this discovery was at once realised, but the quantities required to produce this differential kill were high and a search was made immediately to find more active substances. Of the many compounds tested, two proved to be far more active—namely, 2 : 4 di-chloro-phenoxyacetic acid and 2-methyl-4-chloro-phenoxyacetic acid.

In the meantime, Nutman, Thornton and Quastel (Ref. 13) were reaching the same conclusions by a different approach. Thornton had shown previously that, before the entry of the nodule bacteria into the root hairs of legumes, the root hairs invariably curled. The curling, it was thought, could be caused by growth-promoting substances, and tests showed this to be true. This discovery in turn started a search for the most active compounds and it was found, in 1942, that 2 : 4 di-chloro-phenoxyacetic acid was toxic to clovers and other crop plants.

The result of the pot experiments by Slade, Templeman and Sexton were communi-

cated to the Agricultural Research Council. In consequence, the two phenoxyacetic acid derivatives were included in the 1943 research programme at Imperial College to test their comparative performance in field-scale trials on a variety of weeds and crops. Direct comparisons were made between the growth-promoting substances, copper salts, DNOC compounds and sulphuric acid.

The results to date have been illuminating, yet at the same time perplexing (Ref. 14). Firstly, the investigations have shown that the range of selective weed control can be greatly expanded ; secondly they have revealed the extraordinary specificity of the action of any one compound on different weeds and different crops. At present the basis of knowledge is insufficient to fill in all the detail but, at least in regard to the relative merits of allied compounds, some broad differences have been established.

Taking first the different copper salts, many experiments have confirmed a varying range of activity for weed destruction. Copper (cupric) chloride is the most active, followed closely by copper nitrate, then copper acetate, and finally (a long way behind) by copper sulphate. For example, for the control of yellow charlock, copper chloride at a 1% concentration is more than the equal of copper sulphate at 5.0%. It is not only a question of concentration because copper chloride acts far more quickly. In hot weather the action of copper chloride is complete in less than three hours. Again copper chloride will destroy some weeds which copper sulphate will not—hemp nettle (*Galeopsis Tetrahit*) and bearbind (*Polygonum Convolvulus*) for example. There are other weeds against which copper sulphate is useless but where the chloride gives a partial control, *e.g.*, white charlock (R. *raphanistrum*). Finally, there is a third group of weeds where all the copper salts investigated have proved to be ineffective, *e.g.* corn buttercup (*Ranunculus arvensis*) and knotgrass (*P. aviculare*).

Just as with the copper salts there is an equal variability in the performance of the different DNOC compounds. In the first place, the findings of Harris and Hyslop (Refs. 9 and 15) on the activation of the sodium salt of DNOC by adding ammonium sulphate have been fully confirmed. Whereas for example sodium DNOC gives a partial control of fat hen (*C. album*) and poppies (*Papaver Rhoeas*) the activated spray will bring about complete destruction. It is noteworthy too that even very small quantities of ammonium sulphate will cause a marked effect. One pound of ammonium sulphate per 100 gallons of spray solution has in many experiments resulted in a greater kill, and maximum efficiency has been reached when 5 to 10 pounds have been added.

While the present experiments fully support the American work on the gain in efficiency of the activated sodium salt, they do not confirm the American conclusions that activation is essentially a question of making the solution more acid and thereby increasing the rate of penetration into the shoot. Additions of ammonium sulphate, ammonium acetate and ammonium carbonate all bring about activation, though their effects on the acidity (pH) of the solution are widely divergent. The mechanism appears to be dependent on a number of factors and is still a matter for further study. Nevertheless in attempting to unravel the problem, results of practical importance have been forthcoming. For example when ammonium sulphate is added to a solution of sodium DNOC there will be some exchange between the two substances and thus there will be at least a proportion of ammonium DNOC in solution. It was thought that this ammonium salt might be more active than the sodium salt and therefore in some measure account for the " activation " brought about when ammonium sulphate was added. To test this hypothesis, a comparison was made between the ammonium salt of DNOC, the sodium salt and the sodium salt activated with ammonium sulphate. As a result it was demonstrated that, for many annual weeds, ammonium DNOC is the equal of the activated sodium salt and superior to the sodium DNOC alone. This is true for the destruction of such weeds as fat hen (*C. album*), hemp

nettle (*G. Tetrahit*) corn poppy (*P. Rhoeas*) corn buttercup (*R. arvensis*) and white charlock (*R. raphanistrum*).

The next question was why the ammonium salt behaved differently from the sodium salt. It seemed possible that in the spray droplets ammonia might first be lost to the air; then, in consequence of this loss, particles of DNOC itself would be deposited on the leaves.

The next step therefore was to compare the ammonium salt with a suspension of DNOC :—a suspension because DNOC is nearly insoluble in water. For this comparison tests were made on annual weeds in both autumn and spring-sown cereal crops, to determine whether seasonal differences, such as temperature, operated differentially. This has proved to be so. In spring-sown crops, on balance, the DNOC suspension is more effective than the ammonium salt. There is little to choose between the suspension and the salt for the destruction of the mayweeds (*Matricaria inodora M. Chamomilla*) fat hen (*C. album*). black bindweed (*P. Convolvulus*) and treacle mustard (*Erysimum cherianthoides*), but for white charlock the DNOC suspension is better. On the other hand, for weeds in winter wheat, the ammonium salt has given a higher kill than the suspension. The position is, however, complicated and needs further investigations, since the results at present vary according to the weed species.

Besides the lower temperatures that rule during the early spring spraying of winter wheat, the weather is less certain, and there is more danger of rain washing off the spray solution. It would clearly be an advantage if this washing off could be prevented, and the possibility of employing quick-breaking DNOC-oil emulsions was investigated. From the aspect of being weatherproof the oil emulsions proved to have considerable advantages. As soon as the emulsion had broken, the oil film on the leaf surfaces could not be readily removed, even by heavy rain. Again, in winter wheat crops, compared with ammonium DNOC, DNOC in the oil emulsion gives an equal degree of control at a lower concentration.

In seeking to determine why the sodium and ammonium salts of DNOC and a DNOC suspension all behaved differently, other compounds have been prepared and tested. These fall into two groups. In the one come alternative inorganic salts such as those of calcium, potassium and copper. In the other, the ammonia has been replaced by other compounds having similar chemical characteristics—namely mon-di-and tri-ethanolamine and morpholine. With the inorganic salts, the latest results are, if anything, more complex since the order of activity is again dependent on the kind of weed. For instance, in one experiment all the five salts gave an equally good control of fat hen, whereas, for the eradication of annual nettle (*U. urens*), the sodium and ammonium salts were markedly superior to the potassium, calcium and copper salts. But for Shepherd's purse these differences, though distinct, were far less marked. Equally complex results have been obtained in trials on corn buttercup, cleavers, Venus-Comb (*Scandix Pecten Veneris*) and white charlock.

In contrast to the variable effects of the inorganic salts of DNOC, the ethanolamine and morpholamine compounds have given results which are in good agreement for several weed species. None of them is as active as ammonium DNOC for the destruction of yellow charlock, mayweed, fat hen and corn poppy, but they are somewhat more efficient than the sodium salt. These findings do not therefore support the postulate that the efficiency of the ammonium salt is due to a chemical affinity between the ammonia and the proteins in the leaf cuticle. On such a hypothesis the ethanolamine and morpholamine salts should be more active, since their affinity for the proteins is likely to be greater.

The divergent effects exhibited by the copper salts and DNOC compounds are found again in the case of the selectively toxic growth-promoting substances. Some weed species are equally susceptible to both 2 : 4 di-chloro-phenoxyacetic acid and 2-methyl-4-chloro-

phenoxyacetic acid (sodium salt)*. To others the former (M.C.P.A.) may be more toxic or less toxic that the latter (D.C.P.A.). There is a third group of weeds which are partially resistant, and a fourth class of wholely resistant species.

These two materials are outstanding for the control of white charlock, corn buttercup and Venus' Comb, since they exceed in efficiency all the other herbicides investigated. A further feature is the small quantity of material required—for white charlock and corn buttercup only two pounds per acre, applied as a spray (equivalent to a concentration of 0.2 % at a 100 gallons per acre) is necessary to give complete control. For Venus' Comb the quantity can be reduced to 1.5 pounds per acre and for pennycress and treacle mustard one pound per acre of M.C.P.A. is sufficient.

M.C.P.A. is more toxic to yellow charlock than D.C.P.A. since the experiments to date indicate that double the concentration of the latter is required, *viz.*, 0.1 % as against 0.05%. In fact with M.C.P.A. a nearly complete kill can be achieved with a concentration of 0.025%—that is no more than 4 ounces per acre, *as long as fine weather persists for a few hours after spraying.* If the concentration of M.C.P.A. is raised to 0.1 % (one pound per acre) then, even if the spray is immediately washed off the shoot by rain, a complete control can still be obtained.

This independence of weather conditions is due to the exceptional property that absorption can take place through the shoot or through the root. It is therefore possible to apply M.C.P.A. or D.C.P.A. as dusts instead of sprays—an advantage of great importance in areas where water supplies are short. Because of this root absorption it is possible, by spraying the soil surface before the weed seedlings have appeared above ground, to kill germinating seeds within the soil before they emerge. Such suppression has been achieved for example by using one pound per acre for yellow charlock and treacle mustard, and three pounds per acre for groundsel (*Seneccio vulgaris*) and annual nettle.

In the group of annual weeds which are partially resistant to both D.C.P.A. and M.C.P.A. there are several in which resistance appears to be correlated with the stage of development. In the case of corn poppy good results have been achieved with M.C.P.A (0.2%) as long as the plants are still small and have not reached the " rosette " stage ; once large rosettes have been formed the control is only partial. The stage of development is even more important for the control of fat hen (*C. album*) ; in the cotyledon stage, or when the seedlings have two true leaves, M.C.P.A. may be highly effective ; with more mature plants little if any control may be obtained. Although the evidence is less precise, the same relationship between resistance and age also apparently holds for spurrey (*Spergula arvensis*), ivy-leaved speedwell (*Veronica hederifolia*), hemp nettle (*G. Tetrahit*), and bearbind (*P. Convolvulus*).

Amongst the wholely resistant annual weeds must be included the mayweeds (*M. inodora M. Chamomilla*), corn marigold (*C. segetum*), willow weed (*Polygonum Persicaria*), knotgrass (*P. aviculare*), cleavers (*G. aparine*), chickweed (*Stellaria media*), parsley piert (*Alchemilla arvensis*) and fumitory (*Fumaria officinalis*). In defining resistance it should, however, be stressed that the concentrations employed have been limited to those which are not injurious to cereal crops.

For a direct comparison of the effects of copper salts, DNOC compounds and the phenoxyacetic acid derivatives on the growth and yield of cereals numerous large scale experiments have been undertaken and the grain yields recorded from over a thousand plots of 0.01 acre. In assessing these results, the direct effect of spraying on the crop and the indirect effect through the suppression of weed competition must be taken into account.

Taking first the direct effect, winter wheat has proved to be more resistant than spring-

*For the sake of brevity 2 : 4 di-chloro-phenoxyacetic acid will in future be abbreviated to D.C.P.A. and 2-methyl-4 chloro phenoxyacetic acid to M.C.P.A.

sown oats or barley. Nevertheless the relative toxicity of the various herbicides to all three crops is of the same order. Sulphuric acid at the normal concentrations tends to depress the yield of spring-sown cereals when conditions are unfavourable for a rapid recovery after spraying—that is on light soils in a dry season. This is also true of copper chloride *only when the concentrations employed exceed* 2.0 *per cent. for spring cereals and* 3.0 *per cent. for winter wheat.*

The liability of the DNOC-oil emulsion to damage the cereal crop is at present a drawback to the development of this type of herbicide. The depression in yield is of the same order as that found with sulphuric acid, and again spring-sown cereals are the more susceptible.

With the remaining DNOC compounds—that is the sodium salt, the activated sodium salt, the ammonium salt and DNOC suspensions, there is no evidence of a permanent check to the normal development of cereals when concentrations up to 0.8 per cent. of DNOC are employed. This is equally true for winter and spring-sown cereals.

With the phenoxyacetic acids there is again a dividing line between winter wheat and spring-sown oats and barley. Concentrations up to 0.4 per cent. of M.C.P.A. (equivalent to four pounds per acre) are safe for winter wheat, but for spring barley and oats the safety limit seemingly lies between a 0.2—0.3 per cent. concentration. On the basis of the completed experiments, D.C.P.A. appears to be less selective than M.C.P.A. but fuller information will be available on this point when the 1945 experiments have been completed.

In considering the direct effect of the various herbicides on the cereal it must be stressed that the check to the crop is normally more than offset by the gain due to the elimination of weed competition. In fact in only one out of the sixteen experiments during 1943-44 did any spray treatment significantly lower the yield below that of the unsprayed weedy plots. Over all experiments the average increase in grain yield for the most effective spray treatments has been 19.5 per cent. This mean figure is not indicative of the maximum increases that can be obtained by the suppression of heavy infestations of annual weeds, since, for research purposes, many of the trials have been confined to crops with a low weed initial density. Increases of ninety per cent. in yield have, for instance, been recorded following the eradication of white charlock in spring barley, and of corn buttercup in winter wheat, when the weed densities have been high.

Undersown Cereal Crops. In undersown cereal crops the problems of weed control are rendered more complex since the effects of the various spray materials on the grass and leguminous seedlings must be taken into account. The problem is further complicated by the modern practice, especially on the lighter soils, of sowing the seeds mixture early in the season before the annual weeds have germinated. In consequence, the " seeds " and the weeds may emerge together.

From the point of view of weed control, the most effective results can be obtained by delaying sowing the " seeds " until the weeds have germinated and have been destroyed by spraying. For such spraying the techniques so far suggested need important modification. If sulphuric acid or copper chloride is used, the seeds can be sown a day later. If it is essential to use a DNOC compound then sowing should be postponed for a week to ten days, since earlier sowing has, in experiments, resulted in a poorer final stand. On no account should M.C.P.A. or D.C.P.A. be employed at all, since the residual effects will suppress germination of the " seeds." It has been demonstrated that three weeks after spraying the soil with M.C.P.A. at the rate of one pound per acre, there was an almost complete failure of red clover, white clover and trefoil to germinate, and a thinner stand of rye-grass and cocksfoot.

If early sowing has been practised, it is impossible to spray for weed control when the clovers are in the cotyledon stage and the grasses are young seedlings, since sulphuric acid,

copper chloride, DNOC compounds and both M.C.P.A. and D.C.P.A. will all be highly injurious. It has been found, however, that the resistance of the seedlings increases rapidly as they develop, and it seems probable that some measure of weed control may be attempted once the legumes have developed four true leaves and the grasses are two inches high and have started to tiller. The investigations on this particular problem are still in the experimental stage and, at the moment, it seems that most success is likely to be obtained with copper chloride and M.C.P.A. as long as the concentrations do not exceed 1.0% and 0.025—0.05 per cent. respectively.

Schwendiman and others (Ref. 16) consider that red clover and lucerne will tolerate low concentrations of DNOC compounds at the 4-6 leaf stage. Trials in England on lucerne indicate that the risk of injury is related to the weather conditions at the time of spraying.

Control of Weeds in Flax.

Next to the cereal crops most attention in the research programme has been given to the eradication of annual weeds in flax. Here the scope for weed eradication has been narrowed by the greater susceptibilty of flax to spray damage. It has been established that it is impossible to employ sulphuric acid since, even at low concentrations, the yield of straw and of fibre will be greatly depressed. Again, flax reacts very differently from the cereals to DNOC compounds. Numerous experiments have shown that flax is likely to be seriously injured by DNOC suspensions, by the ammonium salt and by the "activated" sodium salt. Only with the sodium and ethanolamine salts* is the rate of spray damage slight, and then only if the crop is sprayed within critical limits of concentration and stage of development. The same conditions hold for copper chloride.

Flax is most resistant to spraying when it has *passed* the cotyledon stage, *i.e.* over 2 inches and less than 6 inches tall. No damage has been observed in 12 of 13 experiments under these conditions, *so long as the concentration of sodium DNOC does not exceed 0.6% and no more than a 100 gallons of spray are applied per acre.* It is equally important that the sodium DNOC paste shall contain no free DNOC, that no wetting agent has been added. and, that the diluted solution is slightly alkaline.

Copper chloride can be used for some weeds, as an alternative to sodium DNOC as long as spraying is again confined to the period when the flax is from 2-6 inches high. It is also essential to limit the concentration, *viz.*, to 2-3 per cent. The available evidence suggests that flax is less resistant to copper chloride when the weather is warm and sunny.

One of the most interesting features of the flax experiments is the effect of M.C.P.A. on development. It would seem that as long as the spray solution does not exceed 0.2 per cent., neither the yield of seed nor that of straw will be depressed, but the yield of fibre following on scutching can be reduced by as much as 48 per cent. Similar results have also been observed for high concentrations of copper chloride, or DNOC compounds other than the sodium salt. Here too, the injurious effects are reflected not so much in the straw yield in the field, but in the depression of fibre yield in the factory. The effects of M.C.P.A. are still the subject of investigation, since the rate and the time of application are important factors.

Up to the present therefore, recommendations for weed control in flax must be confined to copper chloride or sodium DNOC within the limits of concentration advocated. By using the appropriate herbicide it should be possible to control yellow charlock, penny cress, treacle mustard and bearbind, and to achieve a partial control of fat hen, poppies and hemp nettle, as long as spraying is carried out at the earliest permitted opportunity when the weeds are still seedlings.

*The present costs of the ethanolamine salts of DNOC are so high as to prohibit their use on a field scale.

Control of Weeds in Grasses for Seed Production.

In considering the problem of weed control in under-sown cereal crops it has already been stressed that grasses in the young seedling stage are very susceptible to spray damage by copper salts, DNOC compounds and M.C.P.A. The consequence is that, by the time the grass seedlings have reached a relatively resistant stage (*i.e.* are two inches high and have started to tiller), the weeds have also grown larger and more resistant. In general, unlike the case of cereal crops, the weed flora is usually mixed and may contain species seldom of importance in cereals, *e.g.* chickweed.

Because of this mixed weed flora, and because of the size of the plants, there are many cases where no one material can be used to destroy all the weeds effectively. In consequence, investigations are in progress on the use of mixed sprays or alternatively of double spraying. Firstly, comparisons are being made of the effects of copper chloride, DNOC compounds, sulphuric acid and the phenoxyacetic derivatives either alone or in combination where this is chemically feasible. Secondly, trials are in progress on spraying first with one herbicide and following up after a short interval with a different material. Information is also being sought on the question whether the order of spraying is of importance.

The choice of the spray material is clearly dependent on the weed flora. For example in one spring-sown cocksfoot field, there was by midseason a well developed mixed flora of knotgrass, bearbind, fat hen, medick (*Medicago lupulina*) pimpernel (*Anagallis arvensis*) and speedwell (*Veronica persica*). On the basis of existing knowledge, therefore, sulphuric acid, activated sodium DNOC, ammonium DNOC and a DNOC suspensions, together with M.C.P.A., were tried either as single or double sprays. With the knotgrass no single spray treatment gave more than a 53 per cent. control (ammonium DNOC at 1.2 per cent. plus a wetting agent) and on the remaining weeds an 88 per cent. reduction was obtained with the 1.2% concentration of both ammonium DNOC and the activated sodium salt. But when the results of double spraying are considered, sulphuric acid at 7.5% (vol/vol. basis) followed by M.C.P.A. at 0.4% was the most effective, producing a 90% kill of knotgrass and a 99% control of the remaining weeds.

In another trial on cocksfoot, where chickweed was the principal weed, neither a DNOC suspensions nor the ammonium or activated sodium salts —with or without a wetting agent – controlled the chickweed at a concentration of 1.0%. Sulphuric acid alone was also ineffective but M.C.P.A. at 0.3% gave a partial control. However, complete control was achieved when spraying with sulphuric acid (5.0 per cent.) was followed up either by M.C.P.A. at 0.3% or activated sodium DNOC at 1.0%. The results cited serve to illustrate that, with double spraying, the results may be very different from those obtained when each spray is applied separately. Because of this interaction much further research is required before practical recommendations can be put forward for double or mixed spraying.

A similar position of uncertainty holds for the direct effects of spraying on the grasses, *i.e.*, more research is still required. The existing data indicate that the reactions of grasses are somewhat different from those of the cereals. To date, the check following on sulphuric acid spraying appears to be less than that resulting from spraying with either DNOC compounds or copper chloride. Grasses, it is tentatively concluded, can withstand M.C.P.A. up to 0.3% (3 lbs. per acre) but it must again be stressed that this applies only when the plants are well established. An " emergence " spraying with an 0.1 per cent. solution has given almost complete destruction of the cocksfoot seedlings and if M.C.P.A. is applied as a " pre-emergence " spray less than 0.05 per cent. will inhibit germination. Until, therefore, the stage at which the grasses cease to be susceptible has been fully established for the principal grasses, the employment of M.C.P.A. or D.C.P.A. requires caution.

Future Developments.

In the previous sections it has been possible to make a number of general recommendations for weed control since the researches have reached a stage when definite conclusions can be drawn on several aspects of the problem. There yet remain other investigations which are still in a preliminary phase and on which it would be premature to base farm practice. Nevertheless, since references to some of these developments in this and other countries have already appeared in print, a resumé of the findings to date may indicate both the possibilities, and also the difficulties likely to be encountered, before the techniques can with safety be carried out on the farm.

According to Westgate and Raynor (Ref. 8) the sodium salt of DNOC can be used for weed control in peas so long as the concentration does not exceed 0.4%. Claims to this effect have also been made in France. Experiments in England, however, have given very divergent results. In some trials peas have withstood, without serious injury, concentrations as high as 0.8% of a DNOC suspension and of the ammonium and sodium salts. In other tests, the plants have been almost completely destroyed by a DNOC suspension and the sodium salt at concentrations as low as 0.3%. Similar contrasting results have been obtained with copper chloride (1—3%) and M.C.P.A. (0.1– 0.3%). There is some evidence that the stage of development of the pea, as well as weather conditions at the time of spraying, are factors involved in this varying action. The "safety limits" cannot at the moment be defined, and the spraying of peas in the field is thus attended by a high risk of serious crop injury.

In 1938 Cross (Ref. 17) demonstrated that it was possible to control selectively some weed species in American cranberry bogs by spraying the plantation with light oils of the "paint thinner" type. Further research both in California and in Australia indicated that umbelliferous crops, such as carrots and parsnips, were resistant to kerosene-type oils while many weed species were not. The experiments proved, too, that the composition of the oil is an important factor. It would appear that the percentages of aromatic and non-sulphonatable fractions control the toxicity both to the weeds and the crops. There is the further complexity that if spraying is unduly delayed the roots may have a paraffin flavour.

Initial experiments in 1945 have demonstrated that both carrots and parsnips can withstand spraying with light oils of a "tractor vapourizing oil" type, whereas some weeds have been destroyed (fat hen) and others have not (annual nettle, shepherd's purse). It has been confirmed that the oil type is highly important, since the effects both on the crop and the weeds are very variable. Types differ both in their toxicity to the weed species and in the check which they cause to the crop. Moreover, in the case of spring-sown carrots, the check is greater in the two-true-leaf stage than in four-leaf stage.

Until further research has been undertaken it would be premature for growers to try this new technique. Furthermore, the cost of spraying is very high, since it would appear that at least a 100 gallons of oil are required per acre to obtain an effective cover of the foliage. However, the cost of spraying might be greatly reduced if the active fractions in the oil could be isolated, emulsified and diluted for application. Alternatively emulsions of highly toxic oils may, on dilution, prove to be selective, and research along these lines has been initiated.

So far, the investigations discussed have all been concerned with the eradication of annual weeds and not with the destruction of perennial weeds. In this connection, of the herbicides discussed for annual weed control, only the phenoxyacetic acid derivatives show promise of being effective. The first experiments on creeping thistle, growing in permanent pasture, indicated that M.C.P.A. was the equal of sodium chlorate and ammonium sulphamate; but in subsequent trials a less complete control has been achieved, and further

research is under weigh to determine how far the degree of control is related to the time of spraying and to the stage of development of the plant.

Experiments on the same lines have been initiated for the destruction of buttercups (*Ranunculus acris, R. bulbosus, R. repens*), horsetail (*Equisetum arvense*), dandelion (*Taraxacum officinale*), plaintains (*Plantago spp.*), bracken (*Pteris Aquilinum*) and ragwort (*Seneccio Jacobea*). Already a high degree of control has been obtained for *R. acris* and horsetail, but the conditions under which maximum efficiency is obtainable have yet to be clearly defined. Bracken appears to be resistant.

There is, however, another factor in grassland—namely the effects of sprays on the leguminous plants. The concentrations necessary for the eradication of individual weed species may reach a level where the clovers will either be destroyed or markedly depressed. For wild white clover the existing evidence indicates that resistance is greater in permanent pasture than in new leys. It would thus appear that this toxicity may be a limiting factor in the control of perennial weeds in grassland. However, if the concentrations are such that the legumes are only checked and not destroyed, the check can be offset by suitable grazing management subsequent to spraying.

Conclusion.

From this review it is evident that in recent years there have been a number of major developments in the field of selective weed control. There is, too, little room to doubt that progress in the immediate future will be at an accelerated pace. Because many of the techniques are in their initial phase there is need for the systematic testing of the existing and other similar herbicides on an even wider range of crops and weeds.

It is through this routine research that the expansion of weed control will at first operate. For example trials to date suggest that maize is as tolerant as cereal crops to M.C.P.A. Again, other experiments point to the feasibility of eradicating perennial weeds like thistles from commercial asparagus beds with a late summer dressing of M.C.P.A. There is the further possibility of controlling annual grasses in cereal crops. The basis for this "tour de force" rests on the observations that small-seeded grasses like cocksfoot, at the time of germination, are killed by M.C.P.A. whereas the cereals are not. This differential susceptibility may well apply equally to black grass (*Alopecurus agrestis*) in winter wheat.

Finally, it is essential to regard this period of fact-finding not as the ultimate aim of research but only the penultimate. Once a firm basis of facts has been established, progress will be arrested unless there is a proper understanding of the reasons why related substances differ in their effects on weeds and crops, and in what particular way the compounds are toxic. At present, biologists are woefully ignorant of these more fundamental problems and, because of the complexity of the problems, they may take a long time to solve. Nevertheless it is on the establishment of underlying principles, by the biologists and the chemists working together, that the next strides forward must depend.

Summary.

After the initial discovery fifty years ago that it was possible to control yellow charlock in cereal crops by spraying with copper sulphate, new developments were at first slow. But in recent years a number of highly effective selective herbicides have been evolved and the technique of chemical weed control extended to other crops.

All the investigations point to the extreme specificity of these compounds both in their effects on different weed species and on the several crops. Amongst the developments have been the testing of copper salts other than the sulphate, and it has been found that

copper chloride and copper nitrate are greatly superior to copper sulphate. Copper chloride in particular has the advantages over copper sulphate that much lower concentrations are required, that the spray is quicker acting and that it controls a wider range of weeds. Within specific limits of concentrations (1—3%) it can be employed for weed destruction in cereals and flax.

In the last ten years research in several countries has shown the value of dinitro-ortho-cresol (DNOC) compounds for annual weed destruction in cereals at concentrations of 0.3—1.0%. Small changes in composition are highly important in altering the toxicity of the spray to weeds and crops. A suspension of dinitro-ortho-cresol or of its ammonium salt will, for example, control a wider range of annual weeds than the sodium salt, unless the latter has been "activated" by the addition of ammonium sulphate. These DNOC sprays, unlike sulphuric acid, do not check the cereal and for some annual weeds, such as corn poppies and the mayweeds, are far more effective. As long as the *sodium* salt is employed and the crop sprayed at the correct stage of growth, several weed species can be eradicated from flax.

The latest development has been the discovery that growth-promoting substances, such as 2 : 4 dichloro-phenoxyacetic acid and 2-methyl-4-chloro-phenoxyacetic acid, are selectively toxic to annual weeds in cereals and maize. These new materials at exceptionally small concentrations (0.25 to 3.0 pounds per acre) have killed a number of common annual weeds in cereals. The range of weeds controlled is less than with the dinitro-ortho-cresol compounds but they have proved outstanding for the suppression of white charlock, corn buttercup and Venus Comb.

These growth-promoting compounds alone show promise for the control of perennial weeds, *e.g.* creeping thistle. They have the exceptional feature that absorption can take place both through the shoot and the roots ; in consequence they can be applied either as sprays or dusts.

For the control of annual weeds in onions and leeks, sulphuric acid is the most effective treatment. The growth-promoting substances and dinitro-ortho-cresol compounds damage these crops.

Spraying the seed bed with sulphuric acid just before the crop seedlings emerge can be applied in any case where the annual weeds normally germinate in advance of the crop, *e.g.* onions, carrots, parsnips.

For the eradication of weeds in undersown crops, in grasses for seed production and in grassland, a number of difficulties have yet to be overcome. In the young seedling stage legumes are damaged or killed by both the dinitro-ortho-cresol compounds and the growth-promoting substances. They are least injured by copper chloride. Resistance to spray damage increases with age but even with well-established plants resistance may only be partial. Similarly, grasses cannot be sprayed with these materials as they come through the ground, but spraying is feasible once the seedlings are established.

In the near future the application of methods of selective weed control is likely to be greatly extended, but at the same time the techniques will become more complex since the number and types of compounds increase.

G. E. BLACKMAN.*

DEPARTMENT OF AGRICULTURE,
OXFORD.

*Formerly at the Department of Botany, Imperial College, London.

References

1. E. RABATÉ, "La Destruction des Mauvaises Herbes" Paris. *Librairie de L'Academie d'Agriculture* 1927.
2. E. KORSMO. Undersokelser 1916-1923 over Ugressets Skadevirkninger og Dets Bekjampelse I Akerbruket. *Johansen & Nielsens Boktrykkeri, Oslo*, 1932.
3. BLACKMAN, G. E. "The Control of Annual Weeds in Cereal Crops by Dilute Sulphuric Acid," *Emp. J. Expt. Agric.* 1934-2- 213.
4. BLACKMAN, G. E & TEMPLEMAN, W. G. "The Eradication of Weeds in Cereal Crops by Sulphuric acid and other Compounds." *J. Agric. Sci.* 1936-26-368.
5. BLACKMAN, G. E. & TEMPLEMAN, W. G. "The Nature of the Competition between Cereal Crops and Annual Weeds." *J. Agric. Sci.* 1938-28-249.
6. BISSEY, R. & BUTLER, O. "Experiments on the Control of Mustard." *J. Am. Soc. Agron.* 1930-22-124.
7. ANONYMOUS. "Weed Control" Edited R. O. WHYTE, *Imp. Bur. Past. Forage Crops Bull.*, 27, 1940.
8. WESTGATE, W. A. & RAYNOR, R. N. "A New Selective Spray for the Control of Certain Weeds." *Calif. Agric. Stat. Bull*, 634, 1940.
9. ROBBINS, W. R., CRAFTS, A. S. & RAYNOR, R. N. "Weed Control" *McGraw-Hill, New York*, 1942
10. ASLANDER, A. "Sulfuric Acid as a Weed Spray." *J. Agric. Res.* 1927-34-1065.
11. CLOUSTON, D. & HILL, A. "The Use of Chlorates as Weed Eradicators," *Scott. J. Agric.* 1933-16-196.
12. SLADE, R. E., TEMPLEMAN, W. G., & SEXTON, W. A. "Differential Effects of Plant Growth Substances on Plant Species." *Nature*, 1945-155-497.
13. NUTMAN, P. S., THORNTON, H. G. & QUASTEL, J. H. "Inhibition by 2 : 4-Dichloro-phenoxyacetic Acid and Other Plant Growth Substances." - *Nature*, 1945-155-498.
14. BLACKMAN, G E. "A Comparison of Certain Plant Growth Substances with Other Selective Herbicides." *Nature*, 1945-155-498.
15. HARRIS, L. E & HYSLOP, G. R. "Selective Sprays for Weed Control in Crops" *Oregon Agric Expt Stat. Bull* 403, 1942.
16. SCHEWENDIMAN, A., TORRIE, J. H. and BRIGGS, G. M. "Effects of Sinox, a Selective Weed Spray, on Legume Seedlings, Weeds and Crop Yields." *J. Am. Soc. Agron.* 1943-35-901.
17. CROSS, C. E. "Chemical Control on Cranberry Bogs." *Am. Cranberry Growers Assoc. Proc. Ann Meeting*, 1938-68-13.

LEYS FOR DRY AREAS

THROUGHOUT the country one finds today a strong interest in grassland and in the ley. This interest is no less marked in the drier eastern counties than elsewhere. It will not be denied that the interest existed during the period between the wars but it was, in the main, concerned with the use of grass as a means of reducing financial commitments. Today the stimulated interest is rather in grass as a crop around which can be built up a profitable farming system. Without in any way discounting its incidental values—there is no need but to mention soil fertility as the chief of these—" grass consciousness " recognises the great value of grass in itself. Although, paradoxically, the acreage of " grass " tends to increase during times of depression, grass as a crop can play its full part only in times of high farming.

Throughout the country, but more particularly in the dry areas, leys are regarded as serving either a direct or an indirect purpose—that is to say, they provide livestock fodder and so a cash return, as their main contribution or, alternatively, their main return is through the enhanced yields of succeeding crops. In dry areas the first or direct purpose is usually milk production. Although the distinction between the two purposes is accepted there is no doubt that it is an arbitrary one. The recognition of the importance of the indirect purpose has resulted from a substitution of " grass-mindedness " for " grass-consciousness." As will be emphasised later, grass consciousness was hardly possible in those days when the question of how best to utilise grass, had, perforce, to remain a question.

An examination of the case in relation to milk production immediately raises the question whether the same ends can be achieved equally well by means of permanent pasture. On this particular point evidence is rather incomplete. Certainly it can be shown that, as judged by botanical composition, much of the permanent pasture of the Eastern Counties is of an indifferent nature. Practical experience also indicates that this particular type of pasture can be replaced by an improved one by seeding after a short arable rotation or alternatively by sowing straight after ploughing.

For all that, it would with our present knowledge certainly be premature, if not dangerous, to condemn all permanent pasture simply on the ground that it had not been sown recently. Conversely it is true that all leys cannot be classed as good simply because they have been sown during the last few years. Similarly no arbitrary length of life can be laid down for leys or " permanent " pasture ; so long as they serve their function of providing adequate livestock keep, surely they should remain in grass. For the moment the evidence rather points to management as the controlling factor in the life of the ley or the continued productivity of permanent pasture. If this is so, then the problems of the length of ley, and of the relationship between ley and permanent pasture, will vary from farmer to farmer—both being dependent on the farmer's management ability. The introduction of a sure and simple method of assessing grassland output would do much to improve our outlook towards grass as a whole. Could such a method be found, the plough could follow as a logical measure when production was falling to an uneconomic level.

In order that perspective may not be lost it may be well to emphasise, at this stage, that much of our permanent pasture is fit only for tillage treatment. The badly matted, acid, unproductive swards that the writer has in mind could certainly be improved by other means than ploughing, but there seems little doubt that the plough is the cheapest and quickest solution. This is more especially true today when a period under tillage can be profitably introduced.

The foregoing arguments are based on the ley in relation to animal production, and in particular to milk production, as the main plank in the farming system. A different problem is involved where the main purpose of the ley is to increase soil fertility and so enhance the returns from succeeding arable crops. Evidence is available to show that fertility can be increased by the ley. So long then as the ley can pay its way during its lifetime, its inclusion in the farming system is likely to be profitable. Unfortunately, however, it has happened in the past that the enhanced cash returns from crops succeeding the ley have been insufficient to meet the losses incurred during the lifetime of the ley itself.

This latter consideration has at times called for treatments, intended to make the ley profitable, that caused the prime purpose of fertility-building to be lost. Thus the ley cut continuously for hay, for sale off the farm, loses much of its intended purpose. Similarly the inclusion of Italian and perennial ryegrass in a one-year clover ley may certainly increase hay production and so cash sales, but also it reduces, more or less, the value of the ley as a restorative crop. Especially is this the case on land subject to clover sickness (*Sclerotinia trifoliorum*), in which case the loss of the clover results in a pure ryegrass stand. Under the dry conditions usually experienced such a ley makes limited root growth and so is very limited in value as a fertility builder , further, the evidence, although inconclusive, does suggest that such a ley is capable of carrying over certain cereal diseases.

If livestock products should be saleable at profitable prices in the future then part of the problem is resolved : for then the tillage farmer could think in terms of a relatively stable livestock policy to utilise his leys. The type of ley to be sown, and for that matter whether a ley is to be sown at all, can only be decided in relation to its utilization. The decision could hardly be taken with any degree of safety in those pre-war days when the future of the beef and mutton markets was certain only in its uncertainty. If the future market is reasonably assured, it would remain to provide a regular supply of animal keep, and the present lean period of July—August would need special attention.

The position of lucerne and sainfoin leys can well be discussed at this stage since, in the main, they appear to hold the key to the situation. Both lucerne and sainfoin have two valuable features—their ability to withstand drought and their ability to be cut for hay and yet to serve their purpose as fertility builders, even though the hay be sold off the farm. Because of these two features they seem to fit well into a general scheme for both livestock and tillage farmers and the case for them, especially lucerne, will be considered in greater detail at a later stage.

Before passing to the more technical problems of leys and grassland it is perhaps worth while to state the position they play in some of the drier Eastern Counties. Table I, taken from the Ministry of Agriculture and Fisheries June 4th Returns for 1939 and 1944, clearly shows that no small acreage is involved. Climatic conditions have favoured a high proportion of tillage which is highly productive. By virtue of the same climatic conditions the smaller proportion of leys and permanent grass is generally very unproductive during the dry months from June onwards.

Table I.

	Tillage.		*Temporary Grass.*		*Permanent Pasture.*	
	1939	1944	1939	1944	1939	1944
Essex	340,706	449,893	46,164	78,775	302,803	169,664
Norfolk	606,235	703,897	100,390	90,278	267,621	185,940
Suffolk E ..	248,564	215,296	26,288	31,838	70,651	40,457
Suffolk W. ..	187,741	196,697	24,097	29,715	62,896	36,269
Total	1,383,246	1,565,783	196,939	230,606	703,971	432,330

It is probably correct to say that, so far as drought is concerned, a true picture is not given by a simple comparison of annual rainfall figures. Though situated in one of the

lowest rain belts in the country, the Eastern Counties suffer from drought in particular because of the low *summer* rainfall coupled with high loss of moisture from high temperatures and often extremely drying winds.

Other factors hold back the extension of the ley system in the Eastern Counties ; there are for instance the national problems of fencing and watering ; these are however secondary. The primary consideration is one of economics and this, in a considerable measure, turns on the problem of the establishment of a type of ley that is not cramped by climatic conditions. If this problem could be solved there would seem to be no reason why the area could not produce livestock as economically as the wetter and therefore at present more productive grassland areas of the west and north.

The Establishment of the Ley.

A considerable amount of experience on the establishment of leys has been obtained over the past few years and the position seems to have been reached where successful establishment, if only a few maxims are observed, is no longer a gamble.

Place of the Ley in the Farm Rotation. So long as the land is clean and in reasonable physical and chemical condition, the ley is not exacting as to its place in the rotation. Of the three conditions, freedom from weeds and good tilth are the more important. Weather conditions adverse to the rapid establishment of the sward are generally to be expected, and the additional handicap of early competition with a heavy weed flora can only lead to failure. Again a rough unkind tilth will lead to uneven germination and short-lived seedlings.

If the conditions of cleanliness and tilth are to be obtained it follows that the ley will come soon after a cleaning crop and not as the successor to a long series of corn crops.

The position in regard to so-called direct reseeding, in the Eastern Counties, seems to be that it should be reserved for such fields as do not allow tillage cropping. Not only does a short tillage rotation allow the killing of pasture weeds but better conditions for sowing are invariably obtained when the old turf has become rotted. Many cases of direct reseeding have been observed where the initial "take" of seeds was good but where the ultimate sward was poor due to a heavy intrusion of grassland weeds. Cases have also been observed where, under the normal dry conditions, the old turf had not rotted quickly and in consequence, had formed a drying-out medium in the soil, aggravating drought conditions.

Cultivations before sowing. Where seeding is to be practised immediately following old turf experience shows that earliness of ploughing is of major importance. The thorough discing of the old turf, before ploughing, helps considerably to hasten rotting, and so facilitates good consolidation. Early cultivation is especially important in the case of heavy soils. Thus if sowing is to be done in spring, the initial ploughing should be made in the late summer or early autumn of the previous year. At centres of spring sowing in Essex, in 1943, it was found that on London clay, a very high proportion of the failures occurred when ploughing was done in the same year as seeding. This observation suggests that success depends on getting a firm, fine seed bed. This suggestion is supported by the fact that, on lighter soils, failures were not so closely associated with time of ploughing.

The use of a Cover Crop. In the case of spring sowing opinions differ on the advisability of using a cash cover crop. The use of the cover crop began with the inclusion of the one-year clover ley in the farm rotation. The clover ley, being introduced to replace the bare fallow, clearly would have lost some of its attraction if it had not been undersown in corn. But we should not argue from the one-year to the longer ley. Red clover is a fast establishing plant and, moreover, it is not required for more than one year. The fact that it does not quickly cover the whole surface of the land is therefore of less consequence.

The main argument against the use of a cover crop is that its presence prevents the

early grazing of the developing sward. This early grazing is essential if grasses and clovers are to spread rapidly till they produce a complete ground cover. The argument against a heavy cover crop is still stronger. A lodged cover crop invariably means a poor seed establishment.

Further and more exact experiments are needed to determine just how far a normal cover crop does influence the eventual productivity of the sward. In the meantime the circumstances of the individual farm will determine the choice. The tillage farmer will lean towards the use of the cover crop whereas the dairy farmer, more concerned with immediate grazing, will probably lean towards bare sowing.

Forms of cover crop other than the usual cereal (to be ripened for grain) can be employed ; in fact the inclusion of Italian ryegrass, to serve the purpose, has long been recommended. Preliminary evidence points to the advantage of including in the seeding one bushel of oats or barley with the object of obtaining somewhat earlier grazing. This earlier grazing can be very helpful in mitigating the effects of an imperfect tilth, especially "hollowness," as well as encouraging the early tillering of clovers and grasses.

The use of a cash nurse crop is of course dependent on the time of year at which the ley is to be sown and is normal only when the grasses are spring sown.

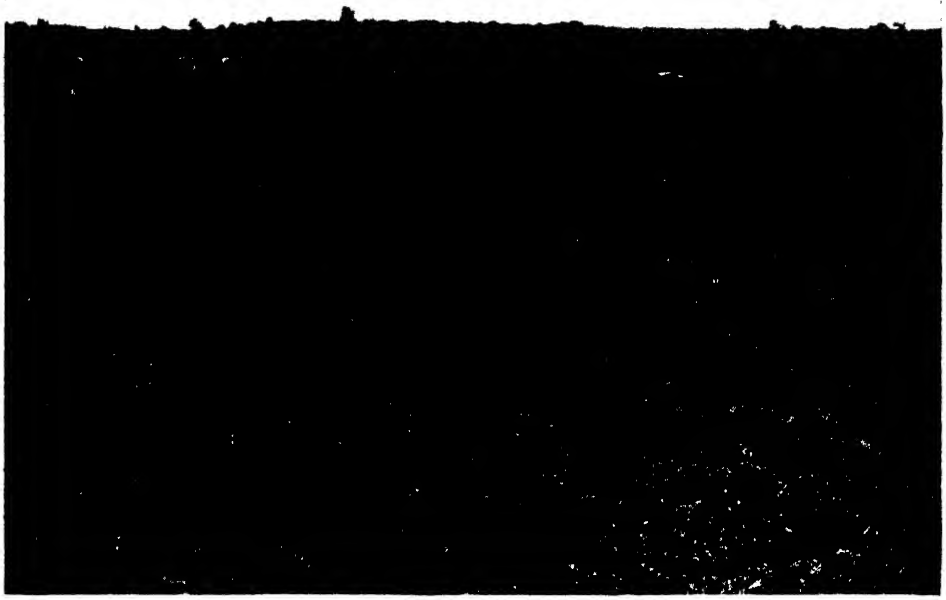
Time of Sowing. The time of year for the sowing of seeds is a further matter of controversy. The long-established practice of spring sowing was based on the undersowing of corn, but of late the preference is turning more and more towards the late summer. The endeavour to seed without a nurse, and yet not to forgo a cash crop, has led to an increase in the practice of seeding after harvest on a disced stubble. Observation of a considerable number of Essex seedings over the past four years has produced much evidence that July-August seedings give a higher proportion of successes than those made in March-April.

The evidence seems fairly conclusive that, if spring sowing is to be adopted, the narrow period from early March to mid-April is the best time. Essex experience is that, unless the young seedlings are fairly established by late May or early June, hot weather and desiccating winds are likely to kill the great bulk of the plants. Incidentally it is at this critical period that a small sowing of oats or barley (for later grazing) seems to do so much to protect the young seeds. In Essex, during the four years 1943-45, conditions for spring sowing proved really good only in 1945. On the other hand the number of failures of July-August sowings recorded over the whole period have been very few. Moreover, as regards 1945, indications at the time of writing are that late summer sowings will be at least as good as those of the spring.

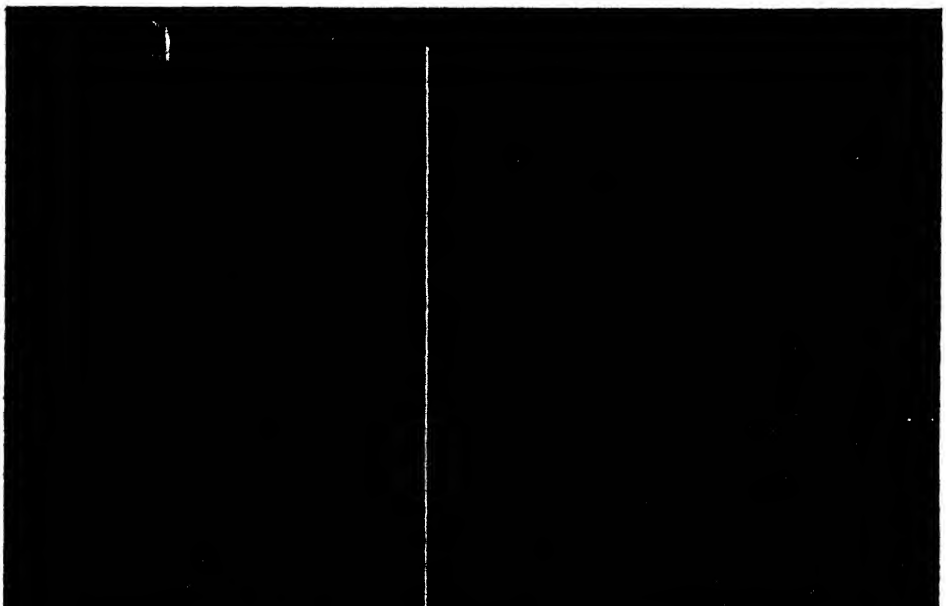
The main criticisms of late summer sowings are that clover establishment is rarely good and also that, especially on the heavier lands, early autumn rain often prevents the all-important early grazing of the establishing sward. Both criticisms have added force when, as often happens through force of circumstances, July-August becomes August-September, or even October. Nevertheless good establishment of grass has been obtained even with sowings as late as October.

Recent work at the Ministry of Agriculture's Grassland Improvement Station tends to show that grasses can be successfully established from sowings made over a long period during winter. If a technique could be obtained of establishing clovers by spring sowings among the already established grass, it would be of possible value under the conditions of the Eastern Counties.

Sowing on disced corn stubbles has proved extremely successful in Essex, and the practice has made considerable progress during the war years. A fine, firm seed bed is readily obtained, whilst the presence of self-sown corn often encourages early grazing and so helps to promote success. Early grazing as a factor in successful establishment will be considered later, but it is as well to emphasise the point at this stage in connection with

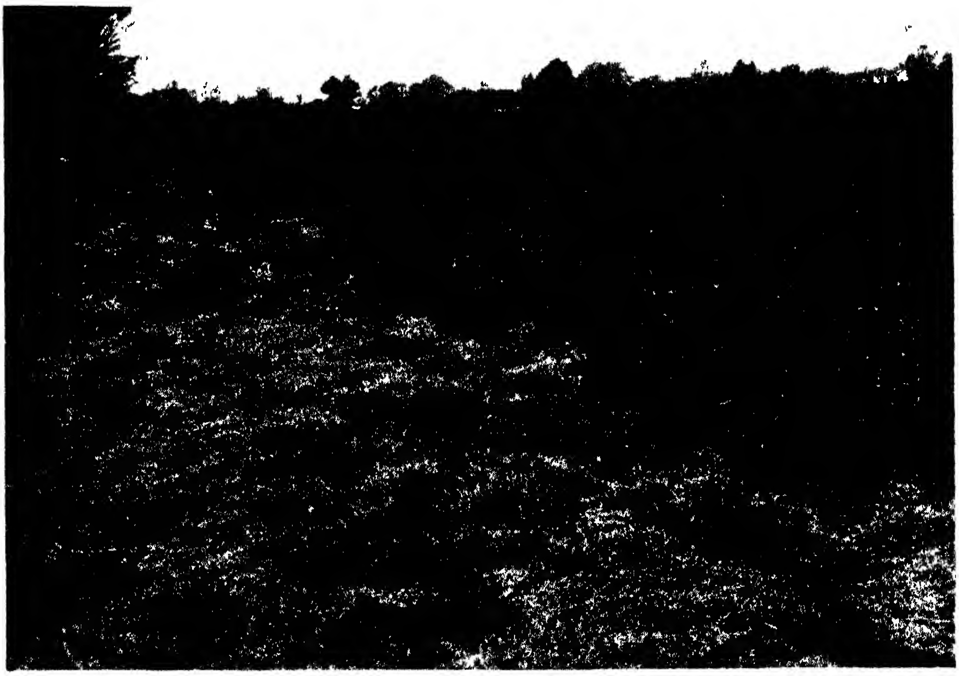


I. THE PROBLEM OF ESTABLISHMENT.—Shewing the effect of cross-drilling. Although fair ground cover is obtained, a good deal of bare ground is discernible. (Seeds drilled 31st March, 1944; photograph taken 5th September, 1944; fertilizers were broadcast).



II. THE PROBLEM OF ESTABLISHMENT.—On the left illustrating the better result with combined fertilizer drilling than with broadcast fertilizers on right. (Photograph taken 130 days after drilling).

III. THE PROBLEM OF ESTABLISHMENT.—A salient feature in the establishment of seeds under corn is that grazing should commence immediately the corn is harvested.



IV. THE ESTABLISHMENT OF LUCERNE.—Liming is a major limiting factor. Initial establishment was regular over the field, but lucerne on left of photo started to die out in the first year. To the right 10 tons small lump chalk applied prior to drilling, to the left no chalk. (Photograph taken 3 years after drilling).

Photos. by G. W. Butcher.

stubble seedings. A number of cases have been recorded, especially with barley, where failure to graze off self-sown corn has led to a failure of establishment. The barley, growing lush, draws up the young grass seedlings, and the onset of wet weather, followed by frost, results in a complete kill of both barley and seeds.

Method of Sowing. Under dry conditions it is essential to obtain maximum ground cover at the earliest possible stage. Bare land leads to a rapid drying out of the top layers of the soil and so to the stunting if not to the death of the young seedlings. Furthermore, bare ground quickly becomes colonised with weeds.

If the soil conditions are ideal there is much to be said in favour of broadcast sowing. In practice, however, ideal conditions are not often obtained and the seeds germinate in a loose, rather rough tilth which tends to dry out very quickly. When broadcast sowings do establish, the sward is very quick in making a complete ground cover. The odds are, however, against good establishment.

Much work remains to be done on the maximum depth at which grass and clover seeds can be sown with safety. Current work at the Grassland Improvement Station indicates that the customary depth might be increased with advantage. It seems logical that the seeds should be placed deep enough to be in the zone of " permanent " soil moisture as opposed to the extreme surface layer which is so variable in its moisture content. This consideration seems to be of greatest importance in spring, since sowings made in July-August are not only less likely to run into long rainless periods, but also there is markedly less loss of soil moisture from that time of the year onwards.

Experience over the past four years has shown that relatively few failures are encountered with spring drilling, but that failures with broadcasting are many. Moreover, the risk of failure with broadcast sowing is greater towards the end of the early-March-mid-April period. With July-August sowings there appears to be little to choose between the two methods except, perhaps, that broadcasting has given the more rapid ground cover.

The position seems to be that under Eastern Counties conditions drilling of seeds would be generally adopted if the disadvantage of relatively slow ground-covering could be overcome. It is difficult to believe that the solution is offered by the introduction of a narrow ($2\frac{1}{2}$—3 inch) spacing drill, since on few farms could the expense of this further implement be justified. Moreover, by reason of the very short seeding season in this area, such a drill would not lend itself to contracting services. Even if the narrow-spacing drill were made convertible for the sowing of a wide range of farm crops, it would be a long time before every farmer changed his existing drill. In the meantime the problem would remain.

The solution seems to rest rather with cross drilling and perhaps also with the more general adoption of the combine drill. Cross drilling alone partially solves the problem but, with spring sowing and the great risk of a check in growth by drought in the year of establishment, the solution is by no means complete. On the other hand, the use of the combine drill shows great promise of providing the almost complete answer, especially where cross drilling is also adopted. At the Essex centres the observed results were remarkable when compared with the standard drilling methods. Fig 11. shows one such example—the photograph was taken 130 days after drilling. The whole area was sown with the same drill fitted with disc coulters at $7\frac{1}{2}$ inch spacing and the difference of treatment of the two plots depicted was :—

(*a*) 2 cwt. per acre Superphosphate (18%) broadcast.

(*b*) 2 cwt. per acre Superphosphate (18%) combine drilled.

The date of drilling (27th April) was deliberately late and sowing was one way only. An interesting phenomenon that has been observed in cases of combine drilling is that the rows of seedlings braird in a much wider band. Whether this is due to the extra " spluttering " of the seeds as they fall with the fertilizer remains to be investigated.

Fertilizers at Sowing. The first consideration is one of lime requirement, and especially so since lime deficiency seems to be aggravated by dry conditions. Where a lime deficiency is present, and even after the application of the amount of lime required, improved results have been obtained by combine-drilling of 1 cwt. per acre of ground chalk together with superphosphate. Cases have been observed where heavy applications of hydrated lime or ground chalk (required to rectify a considerable lime deficiency have resulted in a very patchy establishment. The inference would appear to be that lime requirements should be dealt with well in advance of the sowing of the ley. This practice should, in any case, be adopted to ensure a thorough admixture of the lime and the soil.

Generalizing, phosphates in one form or another are of fundamental importance and it has been found that a relatively small amount, combine-drilled, gives apparently similar results to a much heavier application broadcast. With the limited evidence available the position as regards potash is not so certain. There would appear to be no case for its application except where acute deficiency is known to exist.

There is a good deal of controversy as to the use of nitrogen on leys but, in so far as the establishment year is concerned, nitrogen has a very important part to play, especially on land which has lost heart under prolonged corn cropping. It is essential to encourage rapid growth and so enable early grazing in an endeavour to get rapid ground cover. Liberal dressings, coupled with hard grazing, are justified.

The practice adopted at the Essex Institute of Agriculture Farms, with considerable success, is to combine drill with 2 cwt. superphosphate per acre (with where necessary, 1 cwt. ground chalk) and to apply 2 cwt. Nitro-chalk to the seed bed.

Rate of Seeding. The time-honoured practice is to use from 25-40 lb. of seed per acre and there is as yet insufficient evidence to justify a change. Exact experimentation is needed to check preliminary evidence to the effect that standard rates are grossly in excess of true requirements. Certainly a good many farmers are obtaining as good, if not better, results with much smaller seed rates. Over a considerable period Wye Agricultural College has obtained good results with a seed rate of about 16 lb. per acre and, of late, herbage-seed producers in the area under review have produced first-class swards of ryegrass and white clover with as little as 10-12 lb. per acre.

Initial Management. The management of the ley after sowing and into its first harvest year is often the weakest link in the chain of establishment. The problem will be considered under three heads :—

(*a*) Leys sown under a cash cover-crop,
(*b*) Leys sown under a grazing cover-crop,
(*c*) Leys sown without a nurse crop.

(*a*) Of the cash cover-crops wheat, barley and oats are those more frequently used, but of late flax and linseed have become recognised as useful substitutes. In fact these two latter might become of considerable importance in relation to the spring establishment of leys. By their nature of growth and by reason of their short time on the land, they avoid many of the recognised disadvantages of the corn crops.

On heavy land it is common practice to undersow autumn cereals, notably wheat, and granted the judicious use of nitrogenous top dressings, wheat is the least likely of all cereals to lodge. Further, on the typical heavy soils and with an initially rough autumn tilth, a minimum of harrowing in the spring will obtain an ideal seed bed.

The undersowing of spring cereals is at a disadvantage unless care is taken to choose a variety resistant to lodging. With both autumn and spring cereals it is also advantageous to choose an early-maturing variety, since this allows the seeds to have a long unhampered period for autumn growth.

The disadvantage of all cash cover-crops is that the young plants tend to make long,

spindly, weak growth. This condition is best counteracted by grazing immediately the cover-crop is harvested. In practice a permanent fence need not be set up at this time, and the electric fencing unit has proved of considerable value in meeting the contingency. Intermittent grazing should continue into the early autumn, and later if conditions permit. The indications are that considerable harm can be done by allowing the ley to go through its first winter in a condition of "winter proudness." In the year following sowing fairly heavy stocking, on the "on and off" principle, should be adopted in order to encourage maximum tillering. (Winter proudness is taken to imply sappy, lush growth which is extremely subject to frost or, alternatively, which tends to rot in the bottom).

(*b*) The object of including a small seeding of some cereal at the time of sowing is to allow grazing at the earliest possible moment. Under normal circumstances this can take place as early as three or four weeks after sowing. The aim should be to graze off completely in as short a time as possible. This will involve heavy stocking for a few days, a complete rest until further keep has grown, and then a repetition of the process throughout the season and well on into the autumn. In fact it is suggested that, in the establishment year, the needs of the stock must be made subservient to those of the ley. If this is done the chances are greater that, in succeeding years, the ley can be made to serve the needs of the stock.

Mention should be made of one period when it is not clear whether the foregoing practice should be adopted; the period in mind is from the end of June until far into July, when drought is at its peak. There are some indications that, by allowing more growth at the beginning of this period, and by light stocking, the ley will come through the period more satisfactorily. Experiments on the point are needed, and even after more evidence has been obtained it may be that the treatment will have to be adjusted according to the circumstances of the particular year.

(*c*) It is surmised that this class of ley will come to be largely confined to July-August sowings. By contrast with districts further west and north, grazing is not likely to be available in the dry belt until 10-12 weeks after spring sowing. As a consequence the need for hoof consolidation becomes apparent before keep is available. On the other hand the indications to date are that, with late summer sowings, grazing can commence in a matter of 6-8 weeks. Table II sets out the position as to seedings at the Institute of Agriculture, Writtle, from 1942-45.

Table II.

Field.	(*a*) *Date sown.*	(*b*) *Days between sowing and first grazing.*
1	22.8.42.	216*
2	12.3.43.	109
3	31.7.43.	41
4	25.3.44.	47†
5	26.3.44.	30‡
6	27.4.44.	§
7	28.7.44.	38
8	23.8.44.	198*
9	2.8.45.	39
10	18.8.45.	42
11	17.9.45 & 4.10.45.	64‖

* Early autumn rain prevented grazing until following spring.
† A volunteer cover crop of wild oats and other weeds was obtained.
‡ Sown with 1 bushel oats as grazing cover-crop.
§ Unfenced from field 2 and so run over with cattle from day of drilling.
‖ Rain fell 18.9.45 and stopped drilling until 4.10.45.

With a late-summer sown ley the main thing seems to be to avoid " winter proudness." The normal experience at Writtle has been that the initial clover " take " is not too good and that, with winter proudness, the plant has disappeared almost completely by the following spring. Further, comparing two late-summer-sown swards, the one that had been well autumn grazed was observed to have made the greater ground cover by the following spring.

Before leaving the general question of establishment, the advantages and disadvantages of the three recognised methods may be put as follows :—

(*a*) *Sowing in spring under a cash cover-crop.*

Advantages.

(*i*) The cost of seed is compensated by the cover crop.

(*ii*) There is minimum interval between the last tillage crop and the first grazing; the land is therefore in almost continuous production.

Disadvantages.

(*i*) The chances of successful establishment are relatively poor.

(*ii*) The sward often takes longer to reach full production.

(*iii*) Weeds can grow unchecked during the time the cover crop is on the land.

(*b*) *Sowing in spring without cash cover-crop.*

Advantages.

(*i*) Spring-germinating weeds are controlled by grazing.

(*ii*) Once established, the sward develops quickly.

Disadvantages.

(*i*) The chances of success are not so good as with late-summer sowings since brairding is often delayed. The chances can be improved by the use of a grazing cover-crop.

(*c*) *Sowing in late summer.*

Advantages.

(*i*) The chance of establishing a good grazing for the following year is fairly high.

(*ii*) Good weed control is obtained, so long as grazing commences early.

Disadvantages.

(*i*) Management in the autumn of establishment may prove difficult.

(*ii*) Difficulty may be experienced in obtaining a good clover " take."

It seems that, in Essex, practice is swinging away from spring undersowing in a corn crop towards (*a*) sowing on a disced stubble and (*b*) sowing after corn, in the following spring.

It seems that the ley is a potential instrument in the control of weeds. One interesting case has been recorded where a 1944 spring sowing, without nurse crop, resulted in a first-class establishment under a cover crop of wild oats (*Avena fatua*). Several cases of late summer sowings have been recorded where blackgrass (*Alopecurus agrestis*) provided the volunteer nurse crop. Experimental work is needed in order to explore the position. It is conceivable that, in future, the particular method of establishing the ley may be related to the weed species present.

The type of ley. Although recent evidence suggests that we have reached a stage when the establishment of the ley is no longer a gamble, it is not true that the ley has provided

the answer to the main grassland problem of the dry belt—that of providing keep from the latter end of July until the beginning of September. To date there has been a concentration on the general-purpose ley and, as a consequence, grassland management has in many cases been made if anything more difficult.

Past research work on management has shown that the nature of a sward is influenced by the method, degree and time of stocking. The indifferent nature of many permanent pastures, on what are considered normal fertile lands, is said to result from an excess of stock searching for grass when it is not there, and conversely an insufficiency of stock when there is an excess of keep. The keep provided by permanent grass, if plotted on a graph, would show a sharp rise towards mid-May, followed by a sharp decline into a low trough of production beginning in June and continuing into July-August; a rise during September-October, followed by a further decline into the trough of winter. The general-purpose ley would give a similar graph, except indeed that the peaks would be higher and the troughs therefore relatively lower. As a result the theory of always stocking the ley up to capacity cannot be applied in ordinary practice. The difficulty may be overcome in part by conserving surpluses, during peak growth periods in the form of hay or silage, but the trough of July-August will still remain to be filled by supplementary feeding.

The general-purpose ley is usually based on perennial ryegrass and white clover. True, as in the widely used Cockle Park Mixture, cocksfoot and timothy are often included but, at least during the first few years, ryegrass predominates. Perennial ryegrass can provide its most useful contribution by supplying early spring and autumn keep but, with the rainfall distribution of the Eastern Counties, no amount of management can extend its growth into July and August. Needs must that we look to other species to fill the gap.

Of the grasses available several have the ability to grow on into the summer period and of these cocksfoot shows the greatest promise. Of the legumes certain strains of late-flowering red clover appear quite useful, while S.100 white clover has been observed as a very good companion to cocksfoot. It is however to lucerne that the Eastern Counties can look to provide keep under dry conditions. It is in fact difficult to understand why the crop has not made greater progress.

The Value of Lucerne.

There seems little doubt that lucerne has a big part to play in the future of Eastern Counties farming. There is no British crop plant better able to withstand long periods of dry weather, its ability to enrich the land with nitrogen is unexcelled and as a cultivator of the soil it is unsurpassed. It has the further advantage of relative immunity from pests and diseases. It is therefore all the less understandable that, since its introduction to the country, it has made so little progress.

It is commonly said that the slow progress of lucerne is due to the extreme difficulty of obtaining good establishment but, with the introduction of a simple inoculation process whereby the presence of the specific strain of bacterium responsible for root nodulation can be assured, the principal risk of failure is obviated. A survey carried out in Essex in 1944 showed that lucerne was being grown successfully on all classes of soil—boulder clay, London clay, brick earth, valley gravel and sand. There was no indication that the class of soil, as such, was the limiting factor.

All successful growers were however unanimous on two points, namely the need for drainage and for lime. The position appears to be that unless the soil is well drained success is impossible. As to lime, it has long been recognised that lucerne cannot tolerate any degree of soil acidity. There are moreover indications that on certain soils, acidity must be counteracted some years in advance of sowing if successful establishment is to be ensured. Further investigation is necessary since it is probable that the condition of the

subsoil may have a marked influence on the position. The foregoing remarks apply in particular to a good deal of the London clay in Essex; much of this is deficient in lime and here establishment is by no means certain. On the same soil, but with a different farming history and so no lime deficiency, lucerne is one of the most successful crops grown.

When lucerne is discussed the question of weeds must arise and certainly they are a limiting factor both as regards establishment and also as regards the length of life of the crop. The markedly slow growth of the plant in its first year tends to allow weeds to get the upper hand. Hence there seems no doubt that success with lucerne demands good farming. Its establishment after a long line of cereal crops, with the increasing weed flora that this commonly implies, becomes well nigh impossible.

The concensus of opinion of successful growers is that summer and autumn weeds are the chief trouble. The chief weeds falling in this class are chickweed (*Stellaria media*), corn chamomile (*Anthemis arvensis L.*), mayweed (*Anthemis cotula L.*), groundsel (*Senecio vulgaris L.*), corn speedwell (*Veronica agrestis* L.), and fat hen (*Chenopodium album* L.). The upshot is that more farmers are sowing in the spring than in the late summer. Further a good many claim that, by undersowing in corn, the weeds are checked and that, although perhaps the lucerne in not so strong in the first year, it ultimately comes away the better crop. Nevertheless a fairly strong school exists in favour of early July sowing, after a summer fallow. The position can probably be stated that, before sowing lucerne, a field free from weeds must be available. A summer fallow cannot be relied on to kill annual weeds, but, managed correctly, it can result in the firmly consolidated seed-bed that is essential to the crop. (The apparent contradiction in the foregoing can be explained as follows :—annual weeds germinating in the spring, and more especially the prostrate ones, are stunted by the effect of the corn cover-crop ; subsequent to a summer fallow, remaining weed seeds germinate with rapidity and, the prostrate ones in particular, crowd out the lucerne).

One of the more difficult decisions to make on a farm is whether a take of lucerne is or is not good enough to leave. Experience has led to the conclusion that a good many establishments are prematurely given up for lost. Many cases have been recorded where what appeared to be an almost complete failure has turned into a complete success by the end of the first harvest year. In this connexion mention should be made of the strain Grimm whose establishment is exceptionally slow.

In order to overcome the difficulties of the establishment year some farmers include short-lived companion plants such as broad red clover and Giant sainfoin. Insufficient evidence is available to reach a conclusion on the value of this practice.

Even when successfully established the life of the ley is often no longer than four or five years, since by then so many weeds are present (and so little lucerne) that the plough is the only answer. Many attempts have been made to overcome the difficulty and these may be grouped into two broad classes (*i*) the use of cultivations (*ii*) the use of companion crops.

(*i*) The kind of cultivation that will be possible is of course determined at the time of drilling and it is at this stage that two schools of thought arise. One maintains that drilling should be in 12 in. rows to allow of subsequent inter-row cultivations, the second that drilling should be in rows as close as possible, either 3½-4 in. drills or alternatively 6 or 7 in. rows in two directions. The second school has in mind that, if closely drilled, the crop will act as its own smother against weeds. There is no precise experimental justification for the first method, and certainly it is often the case in practice that the inter-row cultivations, for some reason or other, are not affected. On the other hand, although it is far from complete, the experimental evidence available does show that greater yields of lucerne are obtained by closer drilling. There is however little or no evidence to show that weed infestation is reduced.

Drastic cultivations by means of heavy harrows, and even disc harrows, are advocated by some successful growers; some even go so far as to say that in the late winter or early spring the field should be left with the appearance of bare land. There is no doubt that considerable damage to the crowns of the plants results from such treatment and it is quite possible that, though the primary object of weed destruction is achieved, the yield of the crop may suffer. This is another point worthy of accurate investigation.

The use of Companion Crops. The use of companion or "smother" crops in order to occupy ground to the exclusion of weeds, is showing great promise. Experimental evidence to date indicates that the main purpose can be achieved and at the same time yields enhanced. The two most promising companions appear to be cocksfoot and white clover; other possibilities are timothy and meadow fescue. Perennial ryegrass is used by a good many but its habit of growth does not fit in too well with that of lucerne; neither can it be expected to make any contribution to the keep during the months of July and August.

The Utilisation of Lucerne. In the past the main purpose of lucerne has been to supply hay. Granted good methods of haymaking, there seems little doubt that lucerne hay could be a main source of home-grown protein. Certainly the past few years have shown clearly that it is more reliable than the winter bean crop.

The practice of grazing lucerne is on the increase and the method of taking a cut of hay and grazing the aftermath is gaining considerable popularity. The use of the electric fence, as a cheap and ready method of folding cattle over the crop, provides a means of overcoming both the difficulty of palatability and the danger of "hoven."

Seeds Mixtures.

The history of seeds mixtures is of some considerable interest. The simple mixtures advocated today have come a long way round in the past 200 years, in some respects they have now made a complete circle. In the 18th century simple mixtures of ryegrass, trefoil and clover were used. Early in the 19th century, chiefly as a result of Sinclair's work at Woburn, more complex mixtures became the fashion. The mixtures made full use of all the grass species we know today, with clovers, vetches and other good old grassland herbs. As the century advanced the tendency was towards complexity and this culminated in the extremely complex mixtures of Elliot. It was largely the work of Gilchrist at Cockle Park that led us back to the simple mixtures—the simple mixture he advocated at the beginning of this century is still the most popular today. He was perhaps the first, with his use and recommendation of New Zealand cocksfoot, to appreciate the importance of strain or type in grasses.

It is mainly to the Aberystwyth team of workers that we owe the introduction of improved strains of grasses and clovers. But, without in any way decrying the potential value of the new strains, it is true to say that we have no exact evidence that they are superior under Eastern-Counties conditions. In theory a good many of them should suit, and certainly this seems to be borne out by practical experience. Their relative shyness in throwing up seed heads does make pasture management easier: but against this it is sometimes claimed that palatability has been lost to some extent.

The species available with especial reference to strain type. Before considering types of seeds mixtures an attempt will be made to discuss the species available with special reference to strain types. Evidence cannot be complete until such time as experimental work has been carried out. That a sward looks ideal to the human eye does not of necessity imply that the grazing animal will thrive any the better.

Perennial ryegrass. As has already been stated perennial ryegrass can be expected to make its main contribution from early spring to mid-June and again from September

onwards. The indications are that S.23 and S.101 will carry on into the fore part of the dry season, but this is as a consequence of their later spring start. Under Essex conditions the indications are that S.24 or New Zealand Permanent Pasture Ryegrass will prove to be the most valuable strains. The main criticism of "commercial" seed is the extreme variability of different parcels; a good many have the disqualifying feature of starting stem and seed production almost as soon as they germinate.

Cocksfoot. It is in the main to cocksfoot that we can look for the provision of grass keep in what we know as the off seasons. These include not only July and August but to some extent the late autumn and winter months. Since consideration of the latter period brings in the question of livestock management and housing in relation to the physical condition of the soil (particularly in regard to poaching) little attempt can be made to include it in the scope of this paper. Nevertheless the problem is there for the investigator to tackle, and from a technical viewpoint it is not beyond solution; time will tell whether the practical considerations prove a complete stumbling block.

So far as grasses are concerend, the fact seems to be that it is with cocksfoot strains that Aberystwyth has made its greatest contribution to the Eastern Counties problem. Observation points to S.37 and S.26 as the most promising companions to lucerne, while S.143 may prove the best for inclusion with white clover. Mention should be made of New Zealand Akaroa since it also appears to be a useful type, similar in growth habit to S.37.

Timothy. Timothy is commonly associated with conditions of high fertility and high moisture. For all that, observation over the past four summers (years when rainfall has been below average) has shown timothy making a substantial contribution to the keep—meagre indeed—of permanent pastures in July. Normally a late starter in spring, it seems capable of playing some part in providing grazing at the beginning of the dry summer period. It has been recognised for some time as a companion plant to lucerne. More experience is required before specific use of the grass can be recommended, but if it is to play a part in the dry, scarce-keep period it would certainly seem that those strains which are late in throwing up seed heads will be the more useful, *i.e.*, S.48 and S.51.

Other grasses will need to be considered and studied in relation to July-August growth, and these include meadow fescue, *Bromus inermis* and *Phalaris tuberosa.*

Clovers. Evidence is available to show the wisdom of including a proportion of red clover in the long ley. The purpose served is two-fold: its quick development provides a substantial proportion of the first few years' keep, and also a quicker ground cover is effected as a guard against the invasion of weeds and to some extent against drying out. The position, however, would seem somewhat changed with the advent of S.100 white clover. Of all the herbage plants introduced by the Welsh Plant Breeding Station, there can be no doubt that S.100 white clover is the most popular in the Eastern Counties. Its rapidity of development, coupled with a remarkable rate of recovery after hard grazing and its ability to withstand high temperatures better than the English or wild white types, make its inclusion in most mixtures a matter of obvious wisdom. It can certainly, compared with wild white clover, be criticised on the score of palatability but observation has shown it to equal red clover in this respect. Without in any way belittling the importance of palatability, the point should be made that palatability is of comparatively small importance in times of keep scarcity. The position of S.100 in relation to red clover and wild white clover needs further examination. In the meantime, the inclusion of a persistent type of the red should continue, while with leys of longer duration than three to four years, wild white clover cannot be omitted.

Lucerne. Pre-war work on lucerne strains can be discounted to some extent owing to the prevailing limitation of supplies. Such work indicated the superiority of Grimm but despite this the more widely used strain was Provence. There can be little doubt that

a wide variation exists in the strains of Grimm available today. The present position is that one cannot be exacting as to strain, but there can be no doubt that, with a return to peace, great improvement should be looked for in the future. The indications are that North America, Australia and New Zealand are considerably ahead of us in the matter of lucerne strains.

Sainfoin. The position here is that the more persistent strain, the Common, is very difficult to obtain in a pure state ; most commonly it is mixed to a greater or less extent with the less persistent strain Giant. The work of the Seed Production Committee, Cambridge, in tracing stocks of the Common type should effect a considerable improvement of the position in time.

Specific Seeds Mixtures. The following mixtures, based initially on theoretical considerations, are proving satisfactory under Essex conditions

(*a*) General Purpose—Ryegrass Ley.

18 lb. S.24 perennial ryegrass
6 lb. S.23 ,, ,,
2 lb. Montgomery Late Flowering Red Clover.
1 lb. S.100 white clover.
1 lb. Wild white clover.

28 lbs. per acre.

(*b*) Drought Grazing—Cocksfoot—White clover.

6 lb. S.23 perennial ryegrass.
14 lb. S.26 or S.143 cocksfoot.
2 lb. S.100 white clover.
1 lb. Wild white clover.

23 lbs. per acre.

(*c*) Hay, Silage and Drought-period Grazing, Lucerne—Cocksfoot.

6 lb. S.37 Cocksfoot.
4 lb. S.48 or S.51 timothy.
16 lb. Lucerne.

26 lbs. per acre.

Mixtures (*a*) and (*b*) can be sown with 4—6 lb. Italian ryegrass if desired.

Management.

Under the regime of "grassland mindedness," management had come to be a matter of manuring, liming and cultivations ; with the prevailing trend towards "grass consciousness" it is becoming recognised as involving much wider issues.

It is true to say that the eventual nature of the sward is determined by the manner in which it is treated. Each herbage plant reacts in a different way and one species can be encouraged to the detriment of another. The management, especially in so far as stocking is concerned, should be varied according to the seeds mixture sown and to the purpose that the ley is intended to fulfil.

Ryegrass—White clover leys. The ryegrass ley will make its principal contribution in the spring and early summer and again in the autumn. The main point in management is a period of complete rest during the winter months ; grazing should cease earlier in the

autumn on such fields as are to supply the earliest spring grazing. From a manurial standpoint ryegrass leys demand a high level of fertility. The fertilizers to be supplied will depend on the type of livestock grazing; for example, if cows are used more fertility will be taken off, not only in milk, but also because a good proportion of the dung and urine will be excreted away from the field. Normally nitrogen will not be required with a well established ley on land in good condition: the frequent use of relatively small amounts of superphosphate or basic slag will generally meet the position. Even where the earliest bite is required the resting of the field early in the autumn seems to be more effective than a spring application of nitrogen. Where, however, nitrogen is required preliminary evidence seems to indicate that late September or early October dressings are better than February-March applications.

The practical belief that nitrogen depresses the clover content of a sward seems to be true when the resulting extra growth of grass is not well grazed, for then the clovers, being prostrate in their normal growth, are forced to weaken themselves in competition. Perhaps of more practical significance is the fact that the practice of nitrogenous top dressing is most prevalent on dairy farms and, as a consequence of the enhanced growth, more cows are carried, more dung and urine are excreted away from the field, and so considerable quantities of potash and phosphate are lost. This, unless rectified, leads in turn to a reduced clover population.

Cocksfoot—white clover leys. Cocksfoot ley can supply keep at three periods of the year according to its management—very early spring, July, and late autumn.

As regards manuring, the principles as given for the ryegrass ley seem to apply equally, except perhaps that, since clover does not flourish to the same extent with cocksfoot, there may be a greater case for the judicious use of nitrogenous top-dressings.

With a ley rested from late summer onwards, keep of high quality can be expected in the late autumn, which keep, however, can be left over to the very early spring. Where keep is required for July the indications are that a complete rest from grazing should be allowed during the months of May and June. Depending on the early spring treatment an early cut for hay or silage could be taken towards the end of May to produce aftermath grazing for July. Cocksfoot will not stand continuous hard grazing, so that the main consideration is to allow relatively long periods of rest between grazings

Lucerne—Cocksfoot. From a grazing viewpoint, the main purpose of the lucerne ley is to supply keep at the height of the dry period. Normally the crop is ready to cut for hay at the beginning of June and if then cut the plant will produce adequate aftermath grazing in July and August. This mixture ley tends to be unpalatable and it would therefore seem to be sound practice to cut for hay at different times so as to give a succession of aftermaths for grazing. The use of the electric fencing unit has proved of great assistance in securing even grazing.

Lucerne, even more than cocksfoot, suffers badly from close grazing coupled with short grazing intervals. The ability of the plant to thrive seems to depend on its being able to build up large root reserves. Recognising this, one school of practical thought insists that lucerne should be rested completely from the beginning of September onwards. It is, however, interesting to note that another school is equally emphatic that grazing can continue with absolute safety up to the New Year. This apparent contradiction can perhaps be explained because, granted the observance of a long enough rest in late summer and early autumn, subsequent grazing up to the New Year, or even later, can do little harm to the lucerne, since by then the crop will have died back and the crowns will be adequately protected from damage. In fact it is possible that good would accrue, since grazing would be supplied to a large extent by weeds.

Conclusion.

An attempt has been made to portray the ley problem in relation to dry conditions. The statements of other writers have not been slavishly followed, but rather the case has been built on evidence supplied by experiment and observation. That the attempt is not completely successful is understandable, for there is a serious dearth of precise evidence. Much work remains to be done, the grass crop does not lend itself too well to exact experimentation and it would seem that the answer to a good many of the problems can come only as the result of practical trial and error.

Looking to a future period of stability, a future when a balanced farm system will be not only a profitable undertaking to the individual but an economic necessity to a well-run world, there can be no doubt that the ley will play an ever increasing part ; the drier areas of the country will be no exception.

Acknowledgments.

I am deeply indebted to those Essex farmers, whose co-operation with experiments and demonstrations, and whose ready help in supplying their experiences has made possible over the past four years the collection of a considerable body of evidence. I am equally indebted to my Essex colleagues and in particular to Mr. C. Castrioty and Mr. H. T. E. Smith for help with this paper. Finally my thanks are due to Mr. T. E. Williams, Professor H. G. Sanders, Dr. Thornton and others for supplying references.

B. H. HARVEY.

Essex Institute of Agriculture,
Writtle,
Chelmsford

Bibliography

1 Davies, Wm. — Grassland Map of England and Wales *Agriculture, Vol* 48, No. 2, 112-121.

2 Mansfield, W. S. — Laying land down to permanent grass Rothamsted Conference XI. The making of new grassland, 38-42

3. Mansfield, W. S. — A system of alternate husbandry as applied to heavy soil—the eastern counties 3rd Oxford Farming Conference 1938, 38-46.

4. Davies, Wm. — The establishment and early management of sown pastures—Gt. Britain. *Imperial Bureau of Pastures and Forage Crops, Bull.* 34, 2-21.

5. Snell, W. — Reseeding in West Suffolk. *Agriculture*, Vol. 52. No. 2. 64-66.

6. Garner, F. H. & Sanders, H. G. — Studies with lucerne (*Medicago sativum*)— row distances and "smother" crops. *Journal of Agricultural Science*, Vol. 30, Part 2. 182-188.

7. Thornton, H. S. & Nichol, H. — Some effects of clipping the tops upon the root development of lucerne (*Medicago sativum*), *Journal of Agricultural Science*, Vol. 24. 532-539.

8. Hildebrand, S. C. & Harrison, C. M. — The effect of height and frequency of cutting alfalfa upon subsequent top growth and root development. *Journal of American Society of Agronomy*, Vol. 31, 790-799.

9 Garner, F. H. & Sanders, H. G. — Four year leys ; the inclusion of red clover ; first year management. *Journal of Agricultural Science*, Vol. 29, Pt. 1, 164-173.

10. Mansfield, W. S. — Lucerne and Sainfoin. *Agriculture*, Vol. 52, No. 6, 255-258.

11. Fyfe, J. L. — Sainfoin, *Agriculture*, Vol. 49, No. 4, 208-210.

12. Jones, M. — Grassland Management and its influence on the sward. *Journal of Experimental Agriculture*, Parts 1-5, Vol. 1.

13. Davies, Wm. — Two Grassland Problems. *Journal of the Royal Agricultural Society*, Vol. 105, 115-124.

CROSSBREEDING OF SHEEP

THROUGHOUT the development of British agriculture, from the comparatively simple manorial and earlier systems to the complex organization of production and marketing characteristic of present day farming, sheep breeding has consistently occupied a position of considerable importance.

Variations in the numbers of sheep in Great Britain in the last 40 years are illustrated by the returns in Table I.

TABLE 1.

Total Numbers of Sheep.

	1898	1908	1918	1928	1938	Variation 1938/1898 Percent.
England	15,673,300	15,707,666	12,770,925	12,389,126	13,344,767	—14.9
Wales & Monmouth	3,481,946	3,972,569	3,704,250	4,000,484	4,567,741	+ 31.2
Scotland	7,587,948	7,439,495	6,878,198	7,578,704	7,969,482	+ 5.0
Great Britain	26,743,194	27,119,730	23,353,373	23,968,314	25,881,990	— 3.2

It will be seen, apart from the influence of the Great War, that the numbers of sheep and the importance of the sheep industry have been steadily maintained, excepting in England, where the numbers declined by about one-seventh between 1898 and 1938.

In view of the progressive trend towards the marketing of sheep as fat lambs, the number of breeding ewes will probably give a better index of the trend in sheep breeding than one based on the total numbers of sheep.

TABLE II.

Number of Ewes kept for Breeding.

	1898	1938	Variation Percent
England	5,791,357	5,015,356	—13.4
Wales & Monmouth	1,359,764	2,006,494	+47.6
Scotland	2,986,811	3,383,696	+13.3
Great Britain	10,137,932	10,405,546	+ 2.6

These figures generally confirm those in Table I, but reveal a smaller decline in sheep breeding in England and a considerably greater increase in both Wales and Scotland, with the result that, in Great Britain as a whole, there has also been, not a decline, but a slight increase in the importance of the sheep industry as measured by the numbers of breeding ewes kept in 1938 when compared with the corresponding figure in 1898.

In earliest times, sheep were raised on permanent natural grassland in much the same way as hill and mountain breeds are reared to-day. With the development of arable farming, however, and, in particular, with the general introduction in the 18th century of restorative crops, such as roots and grass and clover leys, many breeds of sheep were gradually transferred from grassland to arable land, where, in association with the Norfolk Four Course, the Wiltshire and other like rotations, they have been treated as hurdled flocks, being kept on arable land almost the whole year, consuming crops specially grown for them.

So long as corn prices were good and wages remained relatively low, the association of sheep breeding with corn growing on medium and light soils was profitable to the farmers and beneficial to the land and arable flocks spread throughout the corn growing districts of Great Britain. It was in this relationship with corn growing on light arable soils that the

term " Golden Hoof " passed into common usage in connection with sheep. In recent years, however, the prices of corn and of fat sheep have failed to keep pace with increases in wages, with the result that the gold of the " Golden Hoof " has to some extent become tarnished.

White (1), in a paper read to the Farmers' Club in 1929, drew attention to this matter and produced figures to show that there had already, at that time, been a considerable decline in the numbers of sheep in the arable corn growing counties, and a corresponding increase in sheep breeding in the grassland and mixed counties. He concluded that grassland sheep generally, and the hill breeds and their crosses in particular, were likely to become progressively more important in the general pattern of sheep breeding in this country.

Askew (2) has published figures confirming the decline in the numbers of certain arable breeds of sheep in their home districts, and illustrating the increase in crossbreeding, presumably mainly with ewes of the grassland type.

Thomas (3) has suggested that there may be a revival in arable sheep farming provided more efficient methods of crop growing, crop utilization and flock management can be achieved, but has failed to enlist much support for this point of view.

Though one may deplore the disappearance of the picturesque and useful relationship of hurdled flocks with corn growing, it seems probable, when existing war-time conditions have passed by, that the trend towards the extended ley and the alternate system of husbandry—first arable crops, then leys, then arable crops again—will be resumed, together with a parallel increase in the popularity and in the numbers of grassland sheep and of the " dual-purpose " breeds and crosses, *i.e.*, those suitable both for grassland and arable conditions.

The World War has brought radical changes to British farming : much grassland has been ploughed up to increase the output of direct human food crops and, with the exception of dairy cattle, all classes of farm livestock have, as a result, declined very considerably in numbers.

TABLE III.
Number of Ewes Kept for Breeding.

	1939	1940	1941	1942	1943	1944	*Variation* 1944/1939 *Percent.*
England & Wales	7,160,000	6,958,000	5,795,000	5,507,000	4,985,000	4,893,000	—31.7
United Kingdom	10,975,000	10,687,000	9,229,000	8,852,000	8,201,000	8,165,000	—25.6

The remarkable increase in food production in this country during the war has not been achieved without some loss of fertility from the soil : this loss should be recognised by all, but must not be accepted as permanent by those who have the ultimate well-being of British farming at heart.

The Minister of Agriculture has already made it clear that, in his view, a return to mixed farming is desirable and that the time has come to plan for the substitution, in 1947 and subsequent years, of leys and other restorative crops, for a proportion of the large area of cash crops now being grown. This development must clearly be accompanied by the rearing of more livestock to consume the crops grown and to supplement the meagre supplies of fresh meat now being produced in this country. By these means, British farming can be geared down from the exhausting tempo of war-time food production and the soil restored to a state of health and fertility.

In this process, sheep will undoubtedly play an important part, especially in light land corn growing districts, and their numbers should therefore be restored, as quickly as possible, to levels similar to those existing in 1939. It is important that the expansion of sheep breeding shall be on sound lines, and that the general policy of sheep farming, as well

It is desirable, therefore, that an endeavour should be made to increase the weight and quality of the fleece, provided the value of the flock for meat production remains unimpaired.

FINANCIAL CONSIDERATIONS.

The profit from rearing a fat hogg or a fat lamb is represented by the difference between the cost of production and the selling price. Individual farmers can increase the selling price only by producing high quality fat sheep and, thereby, obtaining such premiums as are paid for quality; on the other hand, the cost of rearing sheep varies widely according to the suitability of the methods adopted, and it is capable of being reduced to a lower figure on many farms by the adoption of better methods of breeding, feeding and general management.

We must first realise that the cost of growing or buying the necessary feeding stuffs accounts for considerably more than one-half of the total cost of sheep rearing, so that a prosperous sheep industry can only be established and maintained where the management of grassland and the growing of arable crops are satisfactory, thereby providing a suitable, adequate and cheap diet for the sheep.

Apart from the cost of producing or purchasing feeding stuffs, many of the most important characteristics governing the cost of rearing fat sheep and, therefore, the profit they leave, are inherited breed characteristics, so that it is of paramount importance that the breeding policy adopted shall be sound, and that the selecting of breeds and crosses for each particular purpose and set of circumstances shall be done with discrimination and skill.

Amongst the inherited characteristics which affect the cost of producing fat sheep, the following are probably the most important:—

(1) the hardiness or thriftiness of the breeding ewe and therefore the cost of keeping her:

(2) the fertility of the ewe and the number of lambs that she produces:

(3) the mothering and suckling qualities of the ewe and therefore the number, weight and condition of the lambs she rears:

(4) the rate of growth and fattening and therefore the final weight and carcase quality of the fat sheep sold:

(5) the wearing qualities of the ewe and the depreciation that must be charged against the rearing of each lamb.
The ideal ewe should have a long and satisfactory breeding life and should rear a good percentage of twins, so that the depreciation to be charged against each lamb will be at a minimum.

In deciding the particular breeding policy and in choosing ewes and rams for breeding, it is clearly necessary to bear in mind the importance of thriftiness, fertility, mothering and milking qualities and long breeding life in the ewe, as well as size, conformation and other qualities in both the ewe and the ram.

There are in this country at least 28 distinct breeds of sheep, as well as numerous recognised crosses, so that the problem confronting breeders to-day is not one of producing new breeds suitable for local conditions, but rather of selecting, from amongst the breeds and crosses that are already available, those most likely to give satisfactory results.

BREEDING POLICY.

The first cleavage in breeding policy is that of pure breeding compared with crossbreeding. Formerly the majority of sheep reared in this country were pure-bred, but, in

the last 30 to 40 years, crossbreeding has been widely adopted, except on hill and mountain grazings, where the hardy, purebred hill and mountain sheep are still maintained, and on those lowland farms, steadily diminishing in numbers, where purebred flocks of sheep of the Down and Longwool breeds are still kept, mainly now for breeding rams.

The general pattern that has developed in sheep breeding in this country can best be followed by tracing the breeds and crosses from the mountain grazings through to the lowland farms. On high, poor mountain ranges, above the 700 feet contour or thereabouts, the sheep kept are almost exclusively of the purebred mountain breeds, *e.g.* Scotch Blackface, Cheviot, Swaledale, Welsh. On the lower slopes, that is below about 700 ft., draft purebred ewes from the mountain flocks are extensively crossed with lowland rams, for example with Border Leicester rams in Scotland, Wensleydale rams in the North of England and rams of such breeds as the Kerry Hill in Wales. In addition, there have been developed on these upland grazings in Central Wales and the West Midlands, the Kerry Hill and Clun Forest breeds, which correspond very closely in size, hardiness, fertility and suckling qualities with the first cross ewes from the mountain breeds, such as the Greyface (Border Leicester × Blackface), North (Border Leicester × Cheviot) and Masham (Wensleydale × Swaledale). In the Border country between England and Scotland, the North (Border Leicester × Cheviot) has also, to some extent, been developed into a purebred type, by breeding together North rams with North ewes and by careful selection amongst the succeeding generations.

The ewes of these upland breeds, the first cross ewes from the mountain breed and, to some extent, the purebred mountain ewes also, are exported to lowland grazings, *e.g.*, the Midlands, East and South-East of England, where they are kept in flying flocks and crossed with rams of the Down and Longwool breeds for the production of fat lambs and hoggs for fattening on roots.

On these lowland farms, it is a common practice to market all the lambs, both males and females, either as fat lambs or fat hoggs, or as stores for fattening on roots.

It has been the general experience of lowland farmers that a scheme of regularised crossbreeding, as outlined above and based on the mountain and hill ewe, has proved the most satisfactory system of breeding for their purpose, and one which has given profitable results. This conclusion is so widely held amongst lowland farmers that one cannot but assume that it is well founded; and it is interesting to speculate as to why crossbreeding should give better results than pure breeding with the improved lowland breeds. It is probable that the disadvantage of pure-breds, as such, is attributable to the difficulty that has been experienced in evolving pure breeds combining, in high degree, all the characteristics that are necessary to ensure success in sheep breeding on a commercial farm.

Those lowland breeds in which by careful selection, fleshing qualities, early maturity and good conformation have been developed, have generally lost to some degree, in the process, the hardiness, fertility and suckling qualities that are so necessary in a ewe on a commercial farm. Fortunately, the hill and mountain breeds and their crosses, though lacking flesh, early maturity and to some extent also the carcase quality of the lowland breeds, have retained their primitive hardiness and inherent fertility, besides the capacity for producing a good flow of milk on poor grazings.

The crossing of these hill and mountain ewes, and of their first-cross daughters, with well grown, deep-fleshed, high-quality lowland rams produces big crops of lambs which inherit size, flesh and carcase quality from their sires, and, by reason of their mothers' good suckling qualities, are able to develop these characteristics to the full and, therefore, to grow into profitable fat sheep.

It is probable that the expansion of sheep breeding in this country in the future will be mainly on grass leys provided by the system of alternate husbandry, and that, on ordinary lowland farms at any rate, the system of breeding is likely to continue to be based mainly on regularised crossbreeding, on the general lines outlined above.

The next step must be to sift such evidence as is available on crossbreeding in sheep with the object of obtaining some guidance as to the selection of suitable breeds and crosses of ewes and of rams for each purpose and set of conditions.

The problems of crossbreeding in sheep can conveniently be divided into two parts, *viz:*—

(1) the selection of breeding ewes for crossing :

(2) the choice of rams for crossing.

The limited evidence available on the merits of some of the numerous breeds and crosses of sheep in this country has been summarised under these two headings.

SELECTION OF BREEDING EWES FOR CROSSING.

The ideal breeding ewe for crossing on commercial farms must be thrifty, prolific, a good mother and a good suckler, and possessed of good wearing qualities. There is, unfortunately, little information on many of these points, and on others none at all.

Data on the fertility of purebred sheep have been collected and published by Heape (5) and by Nichols (6, 7, 8) and is summarised below.

TABLE IV.

Fertility in Purebred Sheep in Purebred Matings.

Breed.	HEAPE 1896 1897 No. of Ewes.	Lambs per 100 ewes.	NICHOLS 1923 1924 No. of Ewes.	Lambs per 100 ewes.	NICHOLS 1924/1925 No. of Ewes.	Lambs per 100 ewes.	Lambs per ewe (Mean of all records)
Border Leicester	–	–	651	207.0	215	181.0	2.00
Leicester	–	–	434	152.1	189	163.0	1.55
Suffolk	7,170	141.77	1,003	148.7	469	144.3	1.43
Shropshire ...	8,044	136.79			768	162.4	1.39
Dorset Horn ..	8,163	123.63	2,096	150.9	731	136.9	1.30
Oxford Down ..	3,189	119.16	3,465	138.4	654	126.9	1.29
Kent	8,481	124.05	–	–	316	128.5	1.24
Hampshire ...	24,860	114.69	2,328	121.7	314	131.8	1.15
Southdown ..	7,834	109.89	961	127.3	5,014	119.3	1.14
Lincoln	15,789	111.1	1,375	128.1	398	138.9	1.13
Blackface (Scotch)	–	–	5,768	91.75	–	—	.92

Both investigators indicated that, in some cases, the returns were of lambs reared, and did not give an exact picture of true fertility, but, at the same time, the figures do give an indication of the relative fertility of the breeds studied in those years. Both Heape and Nichols concluded there were breed differences in fertility in sheep, and that fertility could be enhanced by good management and, particularly, by flushing the ewes and thereby bringing them into good condition at tupping time. Hammond (9) has also described the practice and underlined the importance of flushing breeding ewes in order to obtain maximum fertility.

WILTSHIRE CROSSBREEDING TRIALS WITH SHEEP.

The results of crossbreeding trials in Wiltshire in 1931 have been reported by Price (10) and are summarised below.

TABLE V.

Matings with Hampshire Down Rams.

Breed	No. of ewes.	No. of lambs conceived per 100 ewes put to ram	Lambs reared per 100 ewes.	Average live weight of lambs weaned (lb.)	Average weight of lambs reared per ewe (lb.)
Kerry Hill	40	160	1.38	71.1	98.1
Suffolk × North	40	160	1.44	71.8	103.4
Exmoor Horn	40	153	1.32	67.0	96.5
North (B.L. × Cheviot) (2 teeth)	40	146	1.27	73.7	93.6
Cheviot	40	140	1.35	64.7	87.3
Southdown × Kent	40	134	1.19	69.7	82.9

In the Wiltshire report, the value of twinning is particularly emphasised, also the usefulness of flushing the ewes as a means of increasing their fertility.

Bonsma (11) in South Africa has recently published the results of a comparison of the milking qualities of Merino ewes with those of crossbreds out of the Merino, by rams of the Romney, Ryeland, Dorset Horn, Border Leicester and Ile de France breeds. He has also compared the milk yields of ewes of the Blackhead Persian breed with crossbreds out of this breed, by Suffolk and Dorset Horn rams. The results are set out below.

TABLE VI.

Average Total Milk Yield for 11 week Lactation Period for Different Breeds and Crosses

Breed.	No. of lactations Recorded	Average Milk Yield in ozs.	Standard Error.	Milk yield expressed as % of Production of Basic Breeds.
Merino	88	2,039	± 68.0	100.0
Romney × Merino	24	2,890	± 165.6	141.7
Ryeland × Merino	24	3,075	± 177.7	150.8
Dorset Horn × Merino	22	3,301	± 181.9	161.9
Border Leicester × Merino	27	3,458	± 171.8	169.6
Ile de France × Merino	33	3,538	± 122.8	173.5
Blackhead Persian	40	1,071	± 38.0	100.0
Suffolk × Blackhead Persian	22	2,632	± 176.3	245.7
Dorset Horn × Blackhead Persian	43	3,314	± 151.4	309.4

These results are of great interest in that they represent the only exact evidence that is available on actual milk yields of ewes produced by crossing with British rams. The number of rams tested in each breed is small but the results point to the transmission of relatively high milk yields by the Border Leicester and the Dorset Horn rams, which confirms the general impression of sheep farmers in this country.

As one would expect, Bonsma found a very close correspondence between the live weight gains made by the lambs and the milk yields of their dams, as determined in the experiments.

YORKSHIRE CROSSING EXPERIMENTS.

A number of sheep crossing experiments have been carried out at Garforth and at Askham Bryan by the late Professor R. S. Seton and his staff in the University of Leeds in

association with the Yorkshire Council for Agricultural Education. Robertson (12) has reported in detail on two of these experiments and the writer (13) has summarised the results of some of the other experiments in a paper read at the meeting, in October 1944, of the British Society of Animal Production.

The earliest experiments at Garforth, extending over a period of 20 years and involving about 1,400 ewes, were designed to determine the merits of the North ewe (Border Leicester × Cheviot) compared with purebred Lincoln ewes. The results of these trials are summarised in Table VII.

TABLE VII.
Matings with Lincoln, Oxford, Suffolk, Hampshire, Shropshire, Wensleydale & Leicester Rams.

Breed of ewe.	No. of ewes put to ram.	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.	Live weight of lambs when weaned (lb.)	Total live weight of lambs per ewe put to ram (lb.)
North (B.L. × Cheviot)	704	1.66	1.45	88.2	128.29
Lincoln	682	1.36	1.02	89.9	91.45

In these experiments, the ewes were mated with rams of various breeds, but throughout, the North and Lincoln ewes were kept under the same conditions. The figures in the last column have been obtained by multiplying together the two previous columns and, therefore, represent the average total live weight of lambs produced per annum per ewe put to the ram. This figure represents fairly completely the true commercial value of ewes for crossing, and has been worked out for each of the experiments reported, where the available figures permitted.

The superiority of the North ewe in these experiments is quite clearly brought out, and was reflected also in the financial returns obtained, which were in favour of the North ewe to the extent of 10/11 per ewe put to the ram: the balance left, per ewe, to meet the cost of feeding, management, labour, overheads and as profit being 40/2¼ per annum in the case of the Lincoln as against 51/1¼ for the North ewe. Similar results have been reported by Wyllie (14) in a comparison between North and Kent cross ewes. He reports that 4,184 North ewes reared an annual average of 1.49 lambs per ewe.

Amongst Down and Longwool breeds, the Suffolk has a good reputation as a grassland sheep. At Askham Bryan a comparison, extending over a period of five years, of purebred Suffolk ewes, in purebred matings, with North Ewes mated to purebred Suffolk rams, has shown the latter to be superior at any rate in the number of lambs reared per ewe put to the ram.

TABLE VIII.
Matings with Suffolk Rams.

Breed of Ewe	No. of ewes put to ram.	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.
North	199	1.97	1.69
Suffolk	303	1.61	1.45

The best of the purebred Suffolk ram and ewe lambs were selected and kept for breeding purposes, so that no direct comparison of the live weight of lambs sold can be made. Though the results obtained with purebred Suffolks were satisfactory, it can be safely said that the bigger crop of lambs reared by the North ewe, combined with her thriftiness and deep milking qualities, made her the more profitable of the two for fat lamb production on a commercial basis.

These results, though they are fragmentary, when taken in conjunction with the

experience of practical farmers, are sufficient to indicate that while the ewes of some Down and Longwool breeds are more suitable for stocking lowland grass than others, they are, on the whole, not likely to be so suitable or so profitable, in commercial flocks under Yorkshire conditions, as crossbred ewes of the type of the North ewe (Border Leicester × Cheviot), which combine in high degree, thriftiness, fertility and good suckling qualities.

The mountain and moorland breeds of sheep out-number all others put together, so that their suitability or otherwise as breeding ewes on lowland grass is a matter of great importance. It is the general experience of lowland sheep breeders that these purebred mountain ewes are not so profitable on good grass as their first-cross daughters by lowland rams. This was certainly the experience at Askham Bryan, as is shown by the results of a comparison, over four seasons, between matings of Suffolk rams with North ewes and with purebred Cheviots, set out below in Table IX.

TABLE IX.
Matings with Suffolk Rams.

Breed of Ewe	No. of ewes put to ram.	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.	Live weight of lambs when sold (lb.)	Age of lambs when sold (days)	Total live weight of lambs per ewe put to ram (lb.)
North	100	1.97	1.73	82.9	106	143
Cheviot	99	1.63	1.44	74.3	126	107

It is the general experience with hill ewes straight from their native grazings that they lamb late in the spring, and that, though potentially reasonably prolific, they suffer a " hang-over " from the unfavourable moorland environment, which depresses their fertility on lowland farms, particularly in the first year. In addition, the weight of the lambs produced by these small hill ewes is less than that of lambs produced by first cross ewes, and they are, on that account, usually less profitable. Fortunately, the hill breeds develop their fertility when kept on lowland grass for more than one year, as illustrated in Table X.

TABLE X.
Matings with Suffolk, Southdown, Shropshire & Ryeland Rams.

Average number of lambs born per Cheviot ewe put to ram.	
First year at Askham Bryan (5 years old)	1.20
Second year at Askham Bryan (6 years old)	1.58

The place for these draft hill ewes is on poor upland grazings, where they should be crossed with the most suitable lowland ram for the production of first cross breeding ewes and of wether lambs to be sold as fat lambs or to be fattened as hoggs in winter. It would be of great benefit, both to the hill sheep farmer and to the farmer on the upland grazings who buys the draft hill ewes, if some means could be found of accelerating the full development of prolificacy in hill ewes when they are removed from their native grazings. Hammond (Junior) (15) and his collaborators have published the results of experiments on hormonal augmentation of fertility in sheep, which may eventually lead to the discovery of a suitable means of enhancing the fertility of mountain ewes, and, indeed, possibly of ewes of all breeds and crosses. A discovery of this kind would be of great value to the sheep industry as a whole.

The results reviewed confirm, so far as they go, the high opinion already held by sheep breeders of the value, in flying flocks, of crossbred ewes such as the North (Border Leicester × Cheviot).

In recent years, purebred Clun Forest and Kerry Hill ewes have become popular in flying flocks, particularly in the Midlands and South of England. The ewes of these two breeds have the reputation of being thrifty, prolific, good mothers and good milkers.

A comparison of North ewes with Kerry Hills, but unfortunately in one year only, is given below.

TABLE XI.
Matings with Suffolk and Hampshire Rams.

Breed of Ewe	No. of ewes put to ram	No. of lambs born per ewe put to ram	No. of lambs reared per ewe put to ram	Live weight of lambs when sold (lb.)	Age of Lambs (days)	Total live weight of lambs per ewe put to ram (lb.)
North	66	1.66	1.56	80.2	172.4	125.1
Kerry Hill ...	74	1.40	1.37	80.8	178.6	110.7

These results are not in agreement with those obtained in Wiltshire (see Table V), where the Kerry Hill gave results superior to the North ewe. In that experiment, however, there was an age difference: the Kerry Hill ewes were aged, while the North ewes were shearlings.

No experimental comparisons are available for Clun Forest ewes: the breeding results from a purebred flock in one year are given below.

TABLE XII.
Purebred Matings of Clun Forest ewes lambing at 2 years old

No. of ewes put to ram.	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.	Live weight of lambs at 6 months old (lb.)	Total live weight of lambs per ewe put to ram (lb.)
189	1.55	1.47	84.5	124.2

These results indicate the usefulness of Clun Forest ewes, but there is obviously a need for thorough-paced comparisons of Clun Forest and Kerry Hill ewes with the North and other crossbred ewes.

The next step should be to consider the merits of various cross ewes, in so far as the requisite information is available.

Experiments at Askham Bryan have provided some evidence on this point though a number of well known crossbreeds, *e.g.*, Greyface (Border Leicester × Blackface) and first crosses from Welsh ewes, have not yet been tried.

TABLE XIII.
Matings with Hampshire Rams.

Breed of ewe.	No. of ewes put to ram.	No. of lambs born per ewe put to ram	No of lambs reared per ewe put to ram.	Live weight of lambs when sold (lb.)	Age of lambs when sold (days)	Total live weight of lambs per ewe put to ram (lb.)	Carcase Grade Index*
North	99	1.98	1.67	81.0	109.3	135.3	4.75
Suffolk × Swaledale	179	1.75	1.63	80.9	112.5	131.9	4.79
Wensleydale × Swaledale (Masham)	172	1.81	1.58	81.7	114.1	128.7	4.77
Border Leicester × Swaledale	135	1.73	1.47	81.5	112.5	120.1	4.75

*The carcase grade index has been got by assigning an arbitrary value to each of the Ministry of Agriculture's carcase grades—Select 5, Prime 4, Good 3 and Reject 2—and calculating the average.

These figures bring out clearly the merit of good first-cross ewes from the mountain breeds for fat lamb production on lowland grass, and particularly the merits of the North ewe.

The majority of farmers are already familiar with North ewes and with Mashams, but the Suffolk and Border Leicester crosses with Swaledale ewes will be new to many. These Swaledale crosses were bred in an experiment that was started in 1933 and completed in 1943.* In 1933 and again in 1936, a purebred Swaledale flock of 150 ewes was very kindly made available for experimental purposes by the late Mr. P. Hudson, Carlabeck, Skipton, and was divided into three equal parts for crossing with Border Leicester, Suffolk and Wensleydale rams on the moorland farm. All lambs were taken over at weaning time, the wethers being fattened and sold as hoggets and all the first-cross ewes were crossed again with Hampshire rams, all the second crosses being sold as fat lambs. The results of this experiment will be published in detail shortly, but the conclusions, briefly, were that each of the three crossbred ewes gave satisfactory results, but the Suffolk × Swaledale and the Wensleydale × Swaledale ewes were, on the whole, superior to the Border Leicester crosses, the latter being somewhat softer and suffering greater mortality both amongst the first-cross ewes and amongst the second-cross lambs. As breeders, the first-cross ewes by the Suffolk rams gave excellent results, but this cross may not prove to be popular with farmers, being short in the leg, variable in fleece type and very mixed in colour, with a considerable amount of black wool in the fleece.

The results illustrated, amongst other things, the manner in which fertility varies with age in these first cross ewes.

TABLE XIV.
Influence of age on prolificacy of first-cross ewes out of Swaledales by Border Leicester, Suffolk & Wensleydale Rams.

		No. of ewes put to ram	Lambs born per ewe put to ram.
1st crop (2 year old)	...	108	1.69
2nd ,,	...	87	1.85
3rd ,,	...	90	1.92
4th ,,	...	77	1.89
5th ,,	...	69	1.84
6th ,, (7 year old)	...	37	2.00

Fertility increased steadily up to the third crop and was well maintained up to the sixth crop of lambs.

The results of the comparisons of the various breeds and crosses of ewes reported here are scarcely sufficient to justify one in drawing many hard and fast conclusions as the experiments have been limited both in number and in scope.

The main characteristics of a good ewe for a flying flock on lowland grass are :-

(1) thriftiness ; she must be able to produce a good crop of lambs and to rear them well without pampering :

(2) fertility ; she should rear, on an average, about 1½ lambs per year :

(3) suckling quality ; she must be a deep milker, so that she produces per year not less than 120 lb. of live weight in her lambs at 6 months old or under :

(4) wearing qualities ; she must be capable of rearing at least five crops of lambs in her lifetime.

The question naturally arises as to where one can find ewes of this type, and the answer seems to be that they exist in most breeds and crosses, but more commonly in some than in others. For general lowland conditions, North, Masham, Greyface, Welsh crosses, Clun Forest and Kerry Hill ewes can be relied on to give satisfactory results and can therefore be recommended with confidence. For the richest pastures the bigger types, such as the North, Masham and Clun Forest, are generally preferred.

The majority of these ewes are derived from hill breeds, so that it is essential, in the interests of sheep breeding as a whole, that the numbers, thriftiness and breeding qualities of the hill breeds generally should be maintained.

It is a common experience in sheep breeding with flying flocks that the ewe, of the two, makes a greater contribution to success or failure than the ram: the ram and the ewe contribute to about the same extent to the inherited make-up of the progeny, but the ewe is mainly responsible for the fertility of the mating and, through her mothering and suckling qualities, she determines the numbers of lambs that survive, also their rate of progress, weight and finish, when sold as fat lambs or stores. At the same time it is essential, in order to get the best results, that rams for crossbreeding should be selected on the right basis and with discrimination.

SELECTION OF RAMS FOR CROSSING.

A number of experiments have been carried out to test the value and usefulness of rams of different breeds for crossing.

In 1930, the Wiltshire County Council (10) carried out an experiment with various breeds of rams which were mated to different breeds and crosses of ewes. Unfortunately, the numbers of lambs produced in these experiments were not reported, but the average weights of single and twin lambs are given in Table XV.

TABLE XV.

Average Live Weights of Lambs weighed in 2nd week in August.

Breed of Ewes.	CHEVIOT		EXMOOR		KERRY HILL		NORTH		WELSH	AVERAGE OF ALL RESULTS EXCEPTING WELSH CROSSES	
Breed of Rams.	*singles* (lb.)	*twins* (lb.)	*singles* (lb.)	*twins* (lb.)	*singles* (lb.)	*twins* (lb.)	*singles* (lb.)	*twins* (lb.)	*All* (lb.)	*singles* (lb.)	*twins* (lb.)
Hampshire	70.53	57.0	66.06	53.08	75.50	61.39	64.28	51.36	60.11	69.1	55.7
Oxford	68.9	57.57	65.11	57.04	73.21	63.76	70.70	56.47	75.83	69.5	58.7
Ryeland	70.70	57.56	63.26	52.28	77.76	60.60	63.08	49.54	63.33	68.7	55.0
Suffolk	73.0	59.27	65.90	58.69	75.40	63.14	67.50	53.18	62.10	70.4	58.5

Fifty ewes of each breed were mated to each ram, excepting in the case of the Welsh, where 10 ewes only were put to each ram.

In these experiments, there was little difference between the weight of single lambs by the different rams, but the twin lambs of the Oxford and Suffolk crosses proved to be somewhat heavier than the others. In this experiment the ewe flocks were carried on different farms, so that the results from the various breeds of ewes are not strictly comparable.

Miller (16), in California, has compared rams of various breeds in crosses with Rambouillet and Romney × Rambouillet ewes for the production of fat lambs. The most important of his results are summarised in Tables XVI and XVII.

TABLE XVI.
Matings with Rambouillet Ewes (Six year average)

Breed of Ram.	No. of ewes bred.	Percentage lamb crop	Age of lambs when sold (days)	Live weight of lambs when sold (lb.)	Pounds lamb per ewe.	Grade Index*
Hampshire	112	135.2	121	77.0	99.0	3.76
Suffolk	112	134.0	120.3	78.3	96.5	3.71
Shropshire	112	127.4	116.8	72.9	87.9	3.81
Southdown	112	130.6	118.1	70.4	88.7	4.01
Romney	74	132.8	115.0	70.0	84.2	3.67
Rambouillet	112	137.4	119.9	70.7	92.1	3.08

TABLE XVII.
Matings with Romney × Rambouillet Ewes (Four year average).

Breed of Ram.	No. of ewes bred.	Percentage lamb crop.	Age of lambs when sold (days)	Live weight of lambs when sold (lb.)	Pounds lamb per ewe.	Grade Index*
Hampshire	80	128.0	95.8	69.5	83.5	3.71
Suffolk	79	126.6	96.2	69.2	87.6	3.77
Shropshire	80	130.0	94.4	62.6	80.6	3.50
Southdown	80	129.5	92.4	60.4	77.0	3.82

*The grade index is a measure of carcase quality determined by assigning an arbitrary value to each grade—Choice 5, Good 4, Medium 3 and Common 2—and calculating the average.

The results reveal the value, under American conditions, of the Suffolk and Hampshire rams for crossing to produce heavy weight lambs, and of the Southdown ram for the production of high carcase quality.

The results of one of the earlier experiments at Garforth extending over five seasons and involving a comparison of rams of various breeds are given below.

TABLE XVIII.
Matings with North Ewes at Garforth.

Breed of ram.	No. of ewes put to ram.	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram	Average gross receipts per ewe per annum
Suffolk	48	1.75	1.68	61/3
Lincoln	48	1.77	1.48	60/4
Oxford	49	1.82	1.71	54/6
Hampshire	50	1.70	1.50	52/10
Shropshire	46	1.50	1.30	43/2

In these experiments the progeny were mainly sold as fat hoggs off roots. Though the numbers are not large and the results should be regarded as indications only, it would appear that the Suffolk and Lincoln crosses, under those conditions, were most profitable, with the Oxford as runner-up.

At Askham Bryan, an experiment extending over four years was conducted to compare Ryeland, Shropshire, Southdown and Suffolk rams for crossing with purebred Cheviot ewes for fat lamb production. The results have been reported in detail by Robertson (11) and are summarised below.

TABLE XIX.
Matings with Cheviot Ewes.

Breed of ewe.	No. of ewes put to ram.	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.	Live weight of lambs when sold (lb.)	Age of lambs when sold (days)	Total live weight of lambs per ewe put to ram (lb.)	Carcase Grade Index*
Suffolk	90	1.63	1.44	74.3	126	107.0	4.00
Southdown	90	1.52	1.40	70.0	140	98.0	4.47
Shropshire	80	1.50	1.29	75 7	124	97.6	4.50
Ryeland	88	1.50	1.30	71.0	127	92.3	4.57

*The grade indices are based on the results in one year only.

In this experiment the Suffolk cross gave the greatest weight of lamb per ewe, also the highest gross returns per ewe, surpassing in this respect its nearest competitor, the Southdown cross, by 3/- per ewe.

In crosses with Masham ewes (Wensleydale × Swaledale) at Askham Bryan, over a three year period, Oxford and Suffolk rams gave similar results and were slightly superior to English Leicester rams, though the differences were scarcely significant.

TABLE XX.
Matings with Masham Ewes.

Breed of ram.	No. of ewes put to ram	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.	Live weight of lambs when sold (lb.)	Age of lambs when sold (days)	Total live weight of lambs per ewe put to ram. (lb.)	Carcase Grade Index.
Oxford	48	1.60	1.54	80.5	126	124.0	4.18
Suffolk	49	1.70	1.51	78.7	125	118.8	4.28
Leicester	49	1.60	1.47	78.0	122	114.7	4.16

At Askham Bryan, crosses by Suffolk and Hampshire rams out of North ewes were compared over a period of five years and the results are given in Table XXI.

TABLE XXI.
Matings with North Ewes.

Breed of ram	No. of ewes put to ram	No. of lambs born per ewe put to ram.	No. of lambs reared per ewe put to ram.	Live weight of lambs when sold (lb.)	Age of lambs when sold (days)	Total live weight of lambs per ewe put to ram (lb.)	Carcase Grade Index.
Suffolk	100	1.97	1.73	82.9	105.9	143.4	4.70
Hampshire	99	1.98	1.67	81.9	109.3	135.3	4.75

In this experiment the Suffolk cross was slightly superior to the Hampshire, but both gave excellent results.

A significant feature in the Yorkshire experiments was the smaller difference in results sometimes obtained from different breeds of rams when compared with differences between various breeds and crosses of ewes. Further, it was not unusual to find a greater difference in results between individual rams of the same breed than that between rams of different breeds.

The results reported are comprehensive neither in respect of the breeds of rams tried nor with regard to the diverse conditions obtaining in different parts of the country, but, at the same time, it is desirable to try to crystalise into definite recommendations the results obtained.

The ideal ram for crossbreeding in flying flocks on lowland farms must transmit to its progeny the following characteristics :—

(1) the ability to grow quickly ; the ram must have scale and must be well grown for his age :

(2) the ability to fatten readily ; the ram must have deep natural flesh and early maturity :

(3) the flesh must be in the right place ; the ram should be particularly well developed in the loin and leg with the minimum of waste.

In short, the ideal ram for crossing must combine size with deep flesh, early maturity and good conformation.

Under Yorkshire conditions, Suffolk, Oxford and Hampshire rams have given very satisfactory results for fat lamb production and can safely be recommended. Of the three, the Suffolk ram has, on the whole, given the most consistent results. For the production of sheep for fattening on roots, Oxford and English Leicester rams have given good results and are generally preferred.

It should be made quite clear that, though these breeds are recommended, suitable rams can also be found for all purposes amongst the other breeds of lowland sheep.

CROSSBREEDING IN SELF-CONTAINED EWE FLOCKS.

Some breeders will be anxious, as far as possible, to establish self-contained flocks on leys or other lowland grass, thereby eliminating the expense of buying in ewes periodically to maintain a flying flock, and also to a large extent excluding those diseases which are commonly brought into the flock with purchased sheep. For this purpose, the Clun and Kerry Hill breeds and those flocks of North ewes that have been stabilised by selection should be considered.

If the Clun Forest or Kerry Hill ewes are used in this way to maintain a self-contained ewe flock for rearing fat lambs or other fat sheep, it is necessary to maintain, as purebreds, one half of the total number of breeding ewes ; the remainder can, with advantage, be first cross ewes by rams, such as the Suffolk, that will transmit to their daughters a reasonable degree of thriftiness, fertility and milking qualities. The pattern in such flocks might well be that one quarter of the ewe flock is made up of purebred ewes mated to purebred rams of the same breed ; one quarter of the ewe flock could be purebred ewes mated to Suffolk or other rams ; the remainder of the ewes, about one half, could consist of first cross ewes, by Suffolk or other rams, mated to Oxford, Hampshire or other rams, or possibly to another ram of the same breed as that used to produce the first cross ewes.

In such a flock, all the second cross lambs would normally be sold fat. It is desirable that all the young purebred ewes be mated to the Suffolk or other rams, and only those older ewes of proven merit should be mated to purebred rams of the same breed to maintain the purebred ewe flock.

The standard for the proven ewe should be that she must have actually produced not less than four crops of lambs, an average of not less than 1½ lambs per crop, and that the average total live weight at six months old or under of the lambs reared by her should be not less than 120 lb. per annum.

Proven rams should also be used, as far as possible, to maintain the purebred flock, and the proven ram should be one that has produced a reasonable number of daughters that come up to the standard for the proven ewe.

The greatest danger in self-contained flocks of this type, based on purebred Clun Forest or Kerry Hill ewes, lies in the tendency amongst lowland breeders to breed and select these hardy flocks on the same lines as the Down and Longwool breeds, by paying undue attention to shortness of leg, depth of flesh and early maturity, and too little attention

to thriftiness, fertility and suckling qualities which, in these breeds, are characteristics of paramount importance. This danger naturally exists in greater degree if rams are bought and selected for breeding purposes as ram lambs, thereby placing a high premium on early maturity. Indeed, thriftiness, fertility and suckling qualities would be more likely to be developed and maintained if purebred rams of the Clun Forest, Kerry Hill and other similar breeds were not shown as ram lambs at all, but kept until they were shearlings before being offered for sale and for use for breeding purposes.

USE OF SECONDCROSS EWES AND OF EWE LAMBS FOR BREEDING.

The present shortage of breeding ewes is likely to continue for a number of years and can best be alleviated by breeding from ewe lambs in their first year and by keeping selected second-cross ewes for breeding purposes.

The practice of breeding from well-grown ewe lambs has already been adopted with good results in certain breeds, such as the Clun Forest and Kerry Hill, and could usefully be adopted more widely.

Experience with these breeds has shown that about half the ewe lambs will breed in their first year, but the proportion varies widely from year to year. Ewe lambs do not usually bring more than one lamb, but will occasionally rear twins. Provided the shearling ewes that are rearing lambs are kept on good pasture, there is very little difference between their weights at 18 months old and those of shearling ewes that have not reared lambs.

In order to get satisfactory results when breeding from ewe lambs, the following conditions should be observed :—

(1) Rams should not be put out before 1st November.

(2) Rams with broad, coarse shoulders should be avoided.

(3) Gimmer lambs must be brought to lambing in forward store condition ; any severe check in condition during the in-lamb period, especially in the last six weeks before lambing, is likely to have dire consequences at lambing time ; with ewe lambs, as with all lowland breeding flocks of ewes, good hay should constitute the foundation of the diet from mid-December to the end of March.

(4) Good pastures, preferably young leys, must be provided for the yearling ewes while they are suckling their lambs, otherwise their growth is likely to be stunted.

If these conditions are observed, breeding results from well grown gimmer lambs of the lowland breeds and crosses are likely to be satisfactory and their subsequent value as breeding ewes is not likely to be impaired.

SUMMARY.

1. Up to the outbreak of the World War, sheep breeding in Great Britain, as a whole, fully maintained its importance.
2. In the last 50 years, due to the pressure of economic factors, there has been a progressive decline in arable sheep farming and in the numbers of those pure breeds commonly associated with close folding on light arable land.
3. During the same period, crossbreeding of sheep has largely replaced pure breeding on lowland farms, and grassland ewes, mainly derived from the mountain breeds, have achieved wide popularity for crossing with purebred rams of the Down and Longwool breeds, both to produce fat lambs and root sheep.
4. During the World War, the number of ewes in the United Kingdom has declined by about one quarter as compared with 1939.
5. With the return to mixed farming and with the establishment of leys, sheep breeding on lowland farms should be restored at least to pre-war levels.

6. Sheep breeding must pay its way without assistance from other branches of farming, and there is considerable evidence that the extended use on grassland, and particularly on good young leys, of thrifty, prolific, deep-milking ewes of the hill breeds and particularly their first crosses, will go a long way to make this possible.

7. The experiments reviewed in this paper and the experience of practical sheep farmers have emphasised the value of ewes of the following breeds and crosses on lowland grass and mixed farms :—

   North (Border Leicester × Cheviot)
   Masham (Wensleydale × Swaledale)
   Mule or Greyface (Border Leicester × Blackface)
   Suffolk × Swaledale
   Border Leicester × Swaledale
   Welsh Mountain crosses by Kerry Hill and Clun rams
   Clun Forest
   Kerry Hill

   On second-class grassland, for example in the foothills, purebred Cheviot, Welsh, Swaledale and Blackface ewes can be recommended for crossing with appropriate rams for the rearing of crossbred breeding ewes and of wether lambs to be sold fat.

8. For mating with ewes of these breeds and crosses to produce fat lambs and fat hoggs, rams from many Down and Longwool breeds have proved to be satisfactory, and the popularity, amongst farmers, of purebred Suffolk, Hampshire and Oxford rams for getting fat lambs, and of Oxford and Leicester rams for siring root sheep, has been confirmed under Yorkshire conditions.

9. Crossbreeding should be regularised and must on no account be allowed to degenerate into "mongrelising": as soon as the supply of breeding ewes is adequate, it is desirable, on the whole, to market second cross lambs—both males and females—for slaughter, and not to breed from them.

10. A sound scheme for crossbreeding can only be established and maintained on the basis of an adequate supply of thrifty breeding ewes from the mountain and hill breeds, and a regular supply of good purebred rams of the Down and Longwool breeds. In the hill and mountain breeds the aim must be, by careful selection, to maintain thriftiness, high potential fertility and good suckling qualities, combined with such degree of size and fleshing as is compatible with the fullest development of the former qualities and with the survival of these sheep under rigorous mountain conditions. In the Down and Longwool breeds, deep flesh, adequate size and good carcase and wool qualities must be wedded to as high a degree of fertility, thriftiness and suckling qualities as can be achieved.

11. Greater standardization in sheep breeding is desirable, but no breed or cross must be abandoned until there is ample proof that it can serve no useful purpose in the sheep industry in the future. Sheep in this country are subject to a diversity of conditions and, in the hill districts in particular, there is much to be said in favour of local breeds that have been selected and bred to meet the conditions peculiar to each particular district. In the case of those lowland breeds from which rams are bought for crossing, one must bear in mind that, in future, there may well be a greater insistence on high carcase quality than at present, which may have the effect of making the rams from the smaller, deeper fleshed breeds more popular and profitable, and therefore more valuable to the industry, than present economic circumstances would seem to suggest.

12. There is an urgent need for more comprehensive and exact experimental and other information on breeds and crosses of sheep in order to provide a satisfactory basis for the planning and establishment of an efficient and enlightened sheep industry in this country.

T. L. BYWATER.

DEPT. OF AGRICULTURE,
THE UNIVERSITY,
LEEDS.

References

1. WHITE, R. G. 1929. Recent Developments in the Breeding and Management of Sheep in Great Britain. *Journal of Farmers' Club* (1929).
2. ASKEW, R. P. 1937. Recent Changes in Sheep Breeding in Arable Areas (I. & II). *Journal of Ministry of Agriculture. Vol.* 44, pp. 450 & 562.
3. THOMAS, J. F. H. 1944. Arable Sheep. Report of Proceeding of British Society of Animal Production, Oct. 1944, p. 43.
4. HAMMOND, J. 1932. Growth and Development of Mutton Qualities in Sheep. *Oliver & Boyd.*
5. HEAPE, W. 1899. Abortion, Barrenness & Fertility in Sheep. *Journal of Royal Agricultural Society*, Series No. 3, Vol. 10, p. 217.
6. NICOLS, J. E. 1924. Fertility in Sheep. *Journal of Ministry of Agriculture, Vol.* 31, p. 835.
7. NICHOLS, J. E. 1926. Fertility in Sheep. *Journal of Ministry of Agriculture, Vol.* 33, p. 218.
8. NICHOLS, J. E. 1926. Fertility in Southdown Sheep. *Journal of Agricultural Science, Vol.* 16, p. 365.
9. HAMMOND, J. 1941. Flushing Ewes. *Journal of Ministry of Agriculture*, Vol. 48, p. 77.
10. PRICE, W. T. 1931. Sheep Breeding Trials. Wiltshire County Council Report.
11. BONSMA, F. N. 1944. Milk Production Studies with Sheep. Union of South Africa. *Bulletin No.* 251.
12. ROBERTSON, G. C. A. R. 1936. Fat Lamb Production. Sheep Crossing Experiments. University of Leeds *Bulletin No.* 183.
13. BYWATER, T. L. 1944. Sheep for Long Leys. Report of Proceedings of British Society of Animal Production, October, 1944, p. 25.
14. WYLLIE, J. 1945. Sheep Breeding and Feeding over six years. *Wye College Report No.* 33.
15. HAMMOND, J. (JNR.) HAMMOND, J., & PARKER, A. S. 1942. Hormonal Augmentation of Fertility in Sheep (I). *Journal of Agricultural Science, Vol.* 32, p. 308.
16. MILLER, R. F. 1935. Crossbreeding Investigation in the Production of California Spring Lamb. University of California *Bulletin No.* 598.

HILL SHEEP PROBLEMS

I. A WELSHMAN'S VIEW

UNDER present conditions the greatest problem facing the hill sheep farmer, especially if he is farming poor land at high elevations, is the economic one. Unless we assume that prices in the post-war period will be at a sufficiently high level to enable him to pay good wages, to accommodate his family and those of his shepherds and men in good houses and with fair amenities, the outlook is poor.

The real hill farmer has to depend for the bulk of his revenue on the sale of draft ewes, wether lambs and wool. The increase in prices from pre-war levels, especially since 1937, has not been sufficient to meet the increase in the cost of production. The prices of store lambs have varied greatly according to the type of lamb produced, time of selling and local demand. Prices and demand for draft ewes from the hills have been consistently low, and the price of wool has been comparatively poor. On the other hand, the cost of labour has more than doubled in most cases, and everything the hill farmer has to buy has increased considerably in price ; had it not been for subsidies for breeding ewes and hill cattle, a large number of hill farmers would have had to give up, and large areas of hill land would have become derelict.

If, then, we are to have a "healthy and well-balanced agriculture" in the future, a number of problems call for consideration. These will be dealt with in the following order :—

(*a*) The human and man power position.

(*b*) The upkeep and improvement of hill farms, including lay-out, pastures, cropping, drains and fences, management, eradication of bracken and the control of heather.

(*c*) Provision for wintering the stock.

(*d*) Breeding and improving the quality of the flock whilst retaining hardiness.

(*e*) Control and eradication of disease.

On the human aspect there is one point I should like to stress. It is that a shepherd's job is a highly skilled one and that, for some years during the pre-war period, there was a definite scarcity of experienced shepherds. What is more important still is the fact that far too few young men were staying on hill farms to gain the necessary skill and experience to enable them to replace the older men. The reasons for this state of affairs are many, and amongst them the following should be noted. It must be realized that the shepherd's job—or maybe it could be better designated 'calling'—is not only highly skilled but at certain seasons, especially during lambing, when he has to be up at the break of day and be out till dark tending his ewes, it is also very exacting. After a hard spring, many of the weaker lambs will have to be nursed and perhaps brought indoors and given a drop from the bottle.

If his hill is unenclosed, the shepherd has again a hard spell after the yearlings return from wintering and until they settle down in their old haunts. During snow storms—which can be terrible experiences—the shepherd has to be out to drive his flock to sheltered areas, where the sheep can obtain some protection from the driving storm and where they can be found after the storm has passed. After a heavy snow storm, if accompanied by a strong wind, there will be large drifts, and many sheep may be buried under snow 10 or 12 feet deep. The task is then to locate the sheep and dig them out. If they have been buried

for many days, they may need careful nursing back to strength. Hill shepherds need to be courageous men, possessed of physical endurance, because they often have to work at considerable risk to health and personal safety.

Houses and cottages, in the great majority of cases, are old-fashioned, badly equipped and lacking in modern conveniences. Usually they are inaccessible and far away from schools and shops; the roads are poor—sometimes non-existent—and transport facilities poor.

As a result of the industrial and urban bias in education during the last century, the drift of country people to the towns, and the conscription of women to the forces during the war, the problem of getting the younger folk to settle down in the countryside will not be an easy one. At the same time it is often comparatively easy to improve farmhouses and cottages by a few simple alterations.

Practically all hill farms have ample water supplies within a short distance of the farmsteads, and where there is no convenient supply the deficiency can generally be overcome without heavy expenditure. Sometimes it is possible to utilise the same source to supply both water and electricity. On the whole the question of electricity is rather more difficult, but there are, in most hill districts, streams or lakes which could be used for generating current to supply a group of holdings and cottages. Telephone facilities should also be extended on the Swedish or Canadian system.

The whole question of rural education needs consideration, especially the curriculum of schools in rural areas. Special courses in hill sheep farming, including management of flocks, simple genetics, prevention and cure of disease, land improvement, cropping, etc., should be established at suitable centres for prospective sheep farmers and shepherds. Given such facilities with favourable prospects for advancement or for suitable shepherds to become flockmasters on their own account, it would be possible, in my opinion, to recruit and retain the better type of young men and women for the countryside.

The whole question of the value and utilization of hill land from a national viewpoint needs to be faced immediately.

In the past the claims of hill sheep farming and forestry have clashed badly. There is no real reason why this should have happened. What is needed is a comprehensive survey of all the hill lands of the country and the allocation of a quota for afforestation. There is a big acreage of hill land that is of little value for hill sheep farming but would grow first class timber, *e.g.*, unploughable bracken areas and steep slopes.

The aim of the Forestry Commission in the past was to plant huge areas to produce timber at the lowest possible cost per cubic foot. From a strictly business point of view this might appear sound, but from a national standpoint it was wrong to destroy a whole rural community. Forestry should be complementary to, and should co-operate with, hill sheep farming to the fullest possible extent, *e.g.*, in relation to shelter belts, heather burning, etc.

The upkeep, improvement and lay-out of hill farms.

The great majority of hill farms suffer badly from lack of fenced enclosures on the lower slopes adjoining the steading, with the result that often the ewes have to lamb on the open hill, with the consequence of a low lambing percentage.

Fenced enclosures would materially help in two ways : (*a*) In the autumn, when the rams are turned out to the ewes on the open hill, they spend a lot of time wandering about, rapidly losing condition. If they were brought down to fenced-in enclosures which had been closed to stock for a short time, the fresh growth would tend to flush the ewes and the restricted range would enable the rams to work more effectively. In this way, fewer and better rams could be used. (*b*) Again, in spring, great benefit could be derived from

enclosures into which the ewes could be brought down to lamb. The shepherding could be done much more effectively and by fewer men, and many more lambs could be saved. Here again an enclosure that has been reseeded is of great value, especially to receive weakly ewes which have little milk. A period of a week or 10 days on good grass makes a tremendous difference to both the ewe and lamb.

There are, of course, a number of hill farms where little can be done in this respect, but on a large number some areas could be enclosed and improved. This would materially increase the production of the holding and so improve its value.

The land for new enclosures should be carefully selected, taking into consideration the following points : suitability of the land for improvement ; aspect and shelter ; water supply ; location and economy in fencing ; accessibility ; drainage.

In many cases land that is not suitable for improvement by cultivation can be enclosed with very good results because of other factors, but in the main it is better to enclose some areas that can be improved by means of cultivation, because it is on these areas that pioneer crops can be grown. They can subsequently be reseeded to provide better winter keep for ewe lambs and paddocks for lambing.

The management of improved swards on hill farms is important because, by adequate liming and manuring and by using a fair percentage of wild white clover and the pedigree grazing strains of grasses (especially cocksfoot S.143 and perennial ryegrass S.23) coupled with good management, it is possible to maintain the swards in a productive condition for a number of years.

The greatest demand on the improved swards on a hill farm is made in spring, and that is the time when the better grasses are at their most vulnerable stage. Continued hard grazing during spring and early summer will kill out the ordinary strains in a few years, but the high tillering pedigree strains will withstand these conditions far better if properly rested and managed during the summer months.

These new pastures should be rested for 10 to 14 days as soon as the sheep have been sent to the open hill in May. During the summer months they should be grazed by cattle ; if, for some reason, all the herbage is not grazed, the pastures should be topped over with a mowing machine. From about the middle of August these reseeded areas should be rested, to conserve keep for winter use.

Incidentally, the resting during this period enables the grasses to develop their root systems and to transfer to the roots reserve material which will materially assist them to withstand the hard spring grazing.

On farms which will allow such a system to be practised the ideal is to plough one area every year and re-seed under turnips and/or rape. The farmer can then every year fatten some of his wether lambs and cull ewes and establish a sward with a fair proportion of Italian ryegrass which will give the earliest spring keep.

Another crop that is worth testing out on a larger scale is winter rye sown in early August. If the season is favourable some autumn grazing can be obtained, but in the main the crop should be managed with a view of obtaining a bulk of spring keep for weakly ewes and lambs. There are large numbers of hill farms where cropping in the ordinary sense of the word is impossible and where only a very limited amount of a forage crop or hay is grown to provide winter fodder for a pony and a cow, or both ; but on some mountain farms even this is not done.

However, with a better lay-out and the fencing of more enclosures and the use of the heavy track type of tractor, the new type of big single-furrow plough, heavy-duty rollers and disc harrows, it is today possible to tackle areas of land which would have been impossible some years ago. In the main this type of land has never been cultivated. The process required is really reclamation of virgin hill land.

There are plenty of enclosures on many hill areas where once stood good farmsteads and fenced enclosures, but where, owing to the depression and neglect of agriculture, the houses and buildings have become ruins, while the enclosures have become part of the open hill. It would be interesting to calculate on the one hand the capital loss to the nation in material and labour that this neglect has meant and on the other the loss of production entailed.

The conservation of grass and other crops by means of silage on hill farms needs far more experimentation and research than has been given to it in the past. There is no doubt that there is a bias against silage-making throughout most areas. Yet in districts of high rainfall it is the safest method of conserving winter fodder. A great drawback to silage-making is the labour involved, but surely it is not beyond the ingenuity of our engineers and machinery experts to devise some means of mechanising the process to a high degree.

On the Cahn Hill Improvement Scheme from 1933 to 1944 some silage was made every year, and during many a year a number of cattle would have had to be sold before the winter had not a fair reserve of fodder been made into silage. The question of machinery will be discussed later.

Large areas of hill land throughout the country have become practically useless because the old drains and open ditches have been neglected. Again in some areas catch pits, made many years ago to collect stone and debris carried down by hill streams during floods, have become blocked, with the result that areas of once useful pasture have become covered with stone and gravel, and are of little use. These two aspects of the drainage problem need serious consideration, and it may be that the question of machinery pools for the use of hill farmers can best be mentioned here.

It has been stressed previously that most of the operations for land improvement in hill areas need track-laying tractors and heavy implements. In my opinion it would be advisable for a body or organization to take over some of the suitable machinery now in the possession of the War Agricultural Executive Committees and to form machinery pools for use on hill farms. This type of machinery is too expensive and difficult to procure, and for even a large-scale hill farmer to buy; but if an organization could acquire the implements and contract to do the work for hill farmers the question would become one of practical politics. There are a number of jobs which such a machinery pool could undertake, *e.g.*, ploughing and cultivating enclosed areas, providing machinery and gang labour for silage making, acquiring and using some of the new ditching and draining machines, using bull- and angle-dozers for levelling land, making roads and tracks to hill areas and using excavators for making dams and catch pits, etc.

Bracken is said to be increasing rapidly and encroaching on once clean land, making such land of little value from a grazing standpoint and being actually dangerous in areas where the maggot fly is prevalent, because the struck sheep lie down and hide in the bracken, are difficult to find, and are often lost. Experiments have been carried out for a number of years both at Bangor and Glasgow on the control of bracken, especially on the value of cutting at various times of the year, and on the use of chemical sprays. It is now recognized that systematic cutting twice a year, in June and in August, is effective in reducing the bracken infestation very considerably in a few years.

Experiments carried out by the writer on the use of chemicals and ploughing have shown that the application of 2 cwt. of sodium chlorate in powder form will completely kill all the bracken and other herbage. The land can then be reseeded after a lapse of about 3 months. If sodium chlorate could be produced at about 5/- per cwt., it might be a very useful material in land reclamation. Other experiments have proved that deep ploughing during June and July results in a practically complete kill even on very strong-growing bracken, and the type of land concerned, when limed and manured, will grow good crops of potatoes or cereals such as oats and rye, and can be easily reseeded to good pastures.

Heather can provide very good sheep keep, especially the young growth during the winter months. A fact that is not sufficiently realized, however, is that, in order to obtain the best results from a heather moor, systematic burning in rotation is absolutely essential. The optimum rotation is said to be somewhere between 10 and 12 years. In the past there has been a clash of interest between the sporting interests and sheep farmers. Gamekeepers have wanted more old heather, to protect and rear the young grouse, than was good for the sheep.

However, there seem to be no real grounds for dispute, especially if the rotation is extended up to 12 years, and it is in the interest of both sheep and grouse that a burning rotation should be properly carried out. Co-operation is necessary so as to disturb the hill as little as possible when the young grouse are newly hatched. Afterwards, it seems that the interests of both run more or less together.

Provision for wintering.

One aspect of this problem, that is, increasing the wintering capacity of hill farms by improving the inbye land through manuring and making more and better hay, is fully dealt with by another writer below.

The other method of improving inbye land (*ffriddoedd*) is by cultivating, manuring and reseeding. This has been in the main the method adopted by the Cahn Hill Improvement Scheme, though many other methods have been tried.

This method has been adopted by a large number of hill farmers in Wales and elsewhere with great success. The war has speeded up this work very considerably, with the result that some counties in Wales have been able to increase their sheep population in spite of the ploughing-up campaign, because a number of the War Agricultural Executive Committees in Wales insisted that a percentage quota of all the enclosed land that was ploughable should be ploughed up. In some instances, the cropping of the inbye land was ordered to comprise mainly pioneer crops and direct reseeding, with the result that more and better winter keep was made available on the hill farms themselves.

A number of War Agricultural Executive Committees have also taken over large areas of hill land for reclamation, using some for wintering sheep and during the summer months for agistment of lowland dairy stock: this has been done in Montgomeryshire. The methods used have been fully described in various articles by Sir George Stapledon and others.

Improvement of the flock.

The term "improvement" as applied to a mountain flock living all the year round on high ground should have a very different meaning from that applicable to a flock grazing on low hills and maybe brought down to winter on cultivated farm land.

In the latter case "improvement" would include improvement in type, body conformation, ability to fatten quickly and quality of wool—all desirable qualities. But if a farmer were to try to produce these improvements in a real mountain flock the probability is that he would be courting disaster: at least such has been the experience of many people who have attempted to do so.

There is a consensus of opinion amongst sheep farmers whose sheep have to live on mountain land during the winter months that the so-called pedigree rams have done a good deal of harm, to counteract which they have to resort to an extreme type of hardy ram in order to keep their flocks up to number. A simple definition of hardiness is difficult to give. It is certainly the most important attribute of a mountain ewe and, once lost, it is exceedingly difficult to recapture. It might be described as the ability to survive under severe climatic conditions, to be able to live in winter on herbage of low nutritive value,

sometimes on the verge of starvation, *plus* a strong mothering instinct and the ability to produce milk under very adverse conditions.

Show standards have had a bad influence on the mountain breeds because the exhibitors, in order to win prizes, have resorted to methods which militated against the maintenance of hardiness, such as keeping the ewes on lowlands even in summer and hand feeding in winter. They have gone so far in many cases as to keep indoors for many months the rams intended for showing. Again, the rams are clipped early, their coats are brushed, combed and trimmed periodically, and all sorts of devices are used to attain so-called perfection. Some of these rams when turned out on the hill waste away and are a sorry sight in a very short time.

These practices are not confined to one breed; indeed flockmasters of all the most important hill breeds are very concerned about the effect of using such rams on their flocks. To condemn breeding of pedigree stock rams for the hill would indeed be wrong, but in order to retain the hardiness of mountain rams different methods are necessary.

It would also be wrong to say that no improvement can be obtained by using a good hardy type of pedigree ram on all flocks. They can be used with success on the lower hills which carry fairly useful swards, and particularly if the ewes are brought to better ground to winter. They can even be used on flocks which graze fairly high mountains in summer but where the ewes are brought down to low ground during the winter. In the case of the flock which grazes summer and winter on high ground the flockmaster must be very discriminating in the choice of fresh blood.

Here the right way is to select rams that are hardy enough to live under the same conditions as the ewes, summer and winter; one is then fairly certain of retaining hardiness. The next step is to select rams for type, conformation, and a good coat suitable for the climate in which the sheep have to live.

There is today a great demand for hardy rams of good quality to improve mountain flocks. There is also room for either new societies or separate branches of the present Mountain Flock Book Societies with entirely new rules and regulations to foster the breeding of hardy rams.

Having obtained a good ram, the best criterion, as with cattle, is the progeny test. There is need for more enclosed paddocks to run these better rams with selected ewes and to select from their progeny rams possessing the desired qualities to run with the bulk of the flock.

Diseases.

Space will not permit a discussion on disease, but in some districts the problem is of very great importance. Whilst during recent year remedies have been found for a great many of the most important diseases, some have not yet yielded to the investigations of the research worker. There is considerable scope for investigation on the interplay of management, special pastures and diseases.

If the recommendations of the two Hill Sheep Farming Committees, whose reports were published last year, are implemented, a number of the problems that have been discussed should be greatly simplified, if not solved, with lasting benefit to the hill sheep industry and to the nation.

MOSES GRIFFITH.

WELSH PLANT BREEDING STATION,
PENGLAIS, ABERYSTWYTH.

II. THE HIGHLANDS OF SCOTLAND

Hill Sheep Farming in the Highlands is a relatively young industry. It was not until after the Jacobite Rebellion of 1745 that the first genuine hill sheep farm in the North or West of Scotland was established. Gradually the suitability for sheep of this virgin area became known and from Argyllshire, where it began, the influx spread gradually north throughout the whole Highland area. Possibly most of these hill sheep farms were created towards the end of the eighteenth and in the early part of the nineteenth centuries and their prosperity appeared to increase progressively up till about the eighties of last century. Since that time there has been a slow but steadily growing volume of complaints that the fertility of the hills is declining, the stock-carrying capacity being lowered and the incidence of disease increasing.

It is true that sheep numbers in the Highland counties have decreased quite markedly. According to figures given in the Scottish Hill Sheep Committee's Report (Ref. 1) there was a 25% reduction in total sheep numbers in the five counties of Argyll, Inverness, Ross and Cromarty, Sutherland and Perth—the five principal Highland counties—between the years 1871-75 and 1938-42. During the same period total sheep numbers in the rest of Scotland increased by 27 per cent. In order that we can see this decline on the hills in true perspective, and form some idea as to whether it can be arrested and if desirable reversed, we must give some consideration to the conditions that prevailed before these hill farms were created.

Two hundred years ago the population of the Highlands was much greater than it is today. Farms were small and numerous in the glens. The principal livestock were cattle, sheep being fewer in number and being kept primarily to provide wool for clothing. An area of ground near to the houses was cultivated for human food and for winter fodder for cattle. The latter kept the lower slopes of the hills closely grazed and, under the shieling system, were taken in summer to the upper parts of the glens and to outlying areas where water and pockets of better soil were to be found. Herding the cattle on these spots kept the herbage under control and quite substantial portions of a township's grazing would be of this type. Bracken there was, but the plentiful supply of manpower prevented it from invading the better grazing areas. Away from the townships the hills carried a varied but plentiful amount of timber, which made excellent shelter for the cattle, both breeding cows and young stock.

With the removal of most of the timber from the Highland hills after 1746, there were opened up large tracts of what was " clean " sheep grazing, and it is not surprising that the sheep farmers who invaded the area from the South of Scotland found it a most successful venture. As landowners learned of the rents that sheep farmers were willing to give they began, by methods not always creditable, to clear the glens of the existing small farmers and their families. It was a topsy-turvy revolution. Whereas previously men and cattle had been relatively numerous and sheep few, now it was sheep that became the dominant factor, while the men were reduced to the number required for shepherding and the cattle to the numbers that the shepherds could handle.

While the immediate results of this change in husbandry were distinctly advantageous to all save the displaced tenantry, who either became crofters on the seaboard, or emigrated, the long-term effects were definitely unsatisfactory. It is now generally agreed that during the last seventy to one hundred years there has been a steady deterioration in the hill grazings, this being most marked in what were formerly the better grazed in-bye and arable grounds. Scarcity of cattle to keep coarser herbage in check has allowed the rough grazing to come creeping right down to the bottom of the glens. Scarcity of men has allowed former arable ground to tumble back to poor pasture, and the fences that once separated some of it from the common grazing to disappear, so that one can hardly tell where the

boundaries once ran. Scarcity of both cattle and men has let bracken creep right down to the homestead.

This is a depressing story, fortunately not one-hundred-per-cent. true but nevertheless very largely so. It is a story of deterioration in condition rather than, as is often suggested, of decline in fertility. The degree of fertility was always low and the actual loss in mineral matter through the annual draft of lambs and cast ewes from a sheep stock that does not number more than one ewe per five acres cannot make much difference to the natural fertility, even in a hundred years. It may be that the deforestation of the Highlands in the second half of the eighteenth century allowed a certain amount of erosion to take place, but the greatest single factor in causing the subsequent steady decline in sheep numbers was undoubtedly the failure to maintain the areas of sweet, good sheep grazing inherited from a husbandry based primarily on cattle and carried out by ample manpower

From this brief historical outline it must be obvious that one major problem facing the Highland sheep farmer is that of adequate nutrition for the sheep stock. Primarily it is that of winter nutrition, since in summer there is ample fresh green herbage, whereas in winter there is only a mass of fibrous, coarse overgrown material, not very suitable for mature animals and wholly unsuitable for young ones. Normally hill ewes in the Highlands are in good condition in the autumn, but by lambing time in spring they may have lost as much as a quarter or even a third of their weight. The fibrous winter diet cannot maintain weight and is a poor preparation for a ewe to nurse her lamb adequately. It is no wonder the percentage lamb crop at weaning is low and, while some of the loss may be due to disease, much of it is just plain starvation.

To alter this downward trend of the last seventy years requires an improvement in quality of parts of the grazings so that ewes can have at least part of their winter diet of a more nutritious nature. An effective though slow way of doing this is by the restoration of cattle to hill grazings. Stewart Wilson (Ref. 2) reported in 1936 that the introduction of twenty Galloway cows to the Boghall hill, which is some 300 acres in extent, was to the advantage of the sheep stock, " the lambs having improved both in size and in quality." He further stated that " while the grazing of cattle on hill land may not give the spectacular results to be derived from surface cultivation followed by the application of phosphates, the cost of reclamation by this method is low, the effect is widespread and the improvement is of a steadily cumulative character."

The Boghall hill is not, however, typical of Highland hill grazing, being in the Southern Uplands of Scotland. There are, nevertheless, farmers in the Highlands who have reintroduced cattle to their hills with beneficial results. Duncan Stewart (Ref. 3), as a result of his experiences in West Perthshire, has stated " cattle will also open up for the sheep many other parts of the hill where the finer grasses have been swamped by the rougher types. On account of this it can be said that, far from causing a diminution in the sheep stock, cattle will help to increase the number of sheep which a hill will carry. At the same time the existing stock will greatly benefit by the improvement in the general grazing on the hill." This experience and conclusion is based on careful observation in connection with the most extensive effort in recent years to restore to former productivity large stretches of hill grazing, that of Ben Challum Ltd., in Glen Lochay. In this connection Stewart stresses the importance of a permanent herd so that there may be continuous cattle grazing all the year round.

As has already been suggested, to depend on cattle alone for an improvement in the quality of the grazing on a hill farm means a wait of several years. Accordingly, where there is former arable land, quicker improvement by cultivation has to be considered. Generally speaking, north of the Grampians only land that was once cultivated as arable is capable of being tackled now, even by modern equipment, and in fact some arable land that might

once have been reasonably well ploughed by horses cannot always be dealt with by modern tractor ploughs. There are, nevertheless, thousands of acres that can be dealt with by modern equipment and, provided the land is adequately supplied with lime and phosphates, it can be reseeded to vastly improved grass with little difficulty.

Direct reseeding, although by far the most successful and the quickest method of effecting an improvement, is also the most costly, despite the quicker returns. Because of its cost it is not really an economic method of dealing with any areas that are unenclosed since, unless the grazing can be controlled, the quality of the improved pasture soon deteriorates. Even if the areas are enclosed they must be used for specific purposes, rather than for general grazing, if a return commensurate with the cost is to be obtained. One such purpose on a Highland hill sheep farm is the wintering of younger ages of sheep. Actually most Highland hill sheep farms find it necessary to winter away on lowland arable farms the ewe hoggs (females between six and twelve months) that are retained for bringing into the breeding flock, since few have arable ground of their own on which the hoggs can be wintered and, since, if they are kept on the hill they make insufficient growth, mature slowly and suffer considerable loss. In fact home wintering, if it is persisted in for several generations, produces a very inferior flock.

In pre-war days the cost of this away wintering was about ten shillings per hogg, a sum considered reasonable in flocks of good standard. This cost had, however, been slightly on the increase, while good wintering had become increasingly difficult to find, partly because of the decline in arable farming between the two wars and partly because some farmers who formerly wintered ewe hoggs had developed breeding flocks of their own. With the big reduction in grassland that followed the ploughing-up campaign early in the war the problem of securing good wintering became very acute and the cost rose until it now ranges up to as much as £1 per head. In relation to existing hill sheep prices this cost is excessive.

There is also a social aspect to the problem. With bigger flocks it is customary for a shepherd to accompany the hoggs, and to herd them throughout the winter months. Normally this task falls to a young but experienced shepherd, and, as it means spending the winter away from his wife and children, it has become increasingly unpopular and is having an effect on the recruitment of young men to hill sheep farming.

With a view to overcoming this problem some consideration has been given to the reseeding of suitable areas on hill farms to allow ewe hoggs to be wintered at home, and an interesting experiment on these lines has been made by Mr. F. S. M. Grant at Knockie in Inverness-shire. The hill on this farm carries a flock of approximately 300 Blackface ewes, and for many years it was customary to send about 100 ewe hoggs away each year for wintering. Included in the lower part of the hill was an area at an elevation of between 600 and 700 feet which was probably once the site of a crofting township, but which must have gone out of cultivation fully one hundred years ago. It had a northerly exposure and consisted of a dry, free soil, of moderate depth and containing boulders. The herbage was mainly bent grass with some bracken and heather. In general many such areas—sometimes enclosed, sometimes part of the outrun—can be found on Highland hill farms.

In 1938 Mr. Grant decided to enclose this area and to improve it. To keep fencing at a minimum involved enclosing 30 acres, of which about 15 acres were ploughable, the remainder being primarily heather on ground never before cultivated and too full of boulders to tackle, even with the most modern equipment. The bracken was cut in late summer and the suitable land then ploughed by tractor. Soil tests having been made, there was applied 30 cwt. Ground Lime, 10 cwt. Basic Slag and 3 cwt. Potash Salts per acre. At the end of the winter the land was cultivated, the bracken roots removed and a seeds mixture sown in a firm seed bed in April 1939.

Since then this area has been managed with the primary purpose of providing winter grazing for ewe hoggs. This is done by alternate resting and grazing as follows :—

(*a*) From the time the hoggs are removed in April the sward is rested for four or five weeks, giving the early and good plants a chance to recover from the heavy winter grazing and to build up renewed vigour.

(*b*) From mid-May to mid-August about twenty Highland cows and their calves are used to graze the area and to eat the herbage down closely, so that any inferior plants that invade the sward are prevented from maturing and becoming established. Cattle have proved extremely satisfactory for this summer control and for preventing the grasses running to seed. An alternative would have been to cut the herbage for hay or silage, but this would have removed more from the land and would also have involved more labour.

(*c*) From Mid-August until the end of September the herbage is again given a complete rest so that it can build up a good leafy growth of four or five inches in preparation for the winter grazing.

(*d*) From early October to mid-April the area is grazed by the ewe hoggs, which receive no other food except in very severe storms, though on occasions they may be allowed an outrun on the hill.

In this way Mr. Grant has been able to winter on this area about 100 ewe hoggs each year since 1939, thus avoiding an expenditure of approximately £75 per annum which might be taken as a moderate estimate of what the away-wintering costs during that period would have been. Careful costs were not kept of the actual operations of reseeding, but with the exception of the fence, which had to be such as would exclude deer, it is known that they fell short of £200. Since then there have been small outlays on fertilizer, chiefly as a reviver, in spring after the heavy winter grazing, but this has been much less than was expected. The cattle-grazing in summer has been remunerative in itself, and Mr. Grant is satisfied that the venture has been most profitable. Where a fence has to be erected this is a costly item and must not be overlooked. In this particular case a deer fence was necessary, but it would be unfair to charge the whole cost of such against the improved area.

A factor of real importance in this case is the survival of the sown grasses. If they had failed to persist, and the sward had needed to be renewed every few years, the project might not have been worth while. Actually there was extremely little deterioration at the beginning of the seventh winter's grazing. If the sward can be maintained for ten years — and on its present showing this is easily possible— it will not only have fully recovered the outlay but have also built up a reserve from which renewal can be met.

An equally important test, in fact the primary test, of successful home wintering is the condition of the ewe hoggs themselves, not only at the end of the winter but as mature ewes in later years. On this score both Mr. Grant and other hill sheep farmers who have seen the flock are satisfied that the hoggs winter as well on this area as they would on an arable farm at a distance and that their subsequent growth and breeding performance is as good. The flock is in no way deteriorating. This result is in keeping with other experience. In the winter of 1944-45 the ewe hoggs on the Glensaugh Hill Experimental Farm of the North of Scotland College of Agriculture were divided into two lots, one of which was wintered at home on old arable land, fenced from the hill and ploughed and reseeded, while the other was wintered on arable pastures elsewhere. In this case the home-wintered hoggs actually put on a greater liveweight increase during the winter and, in appearance, looked definitely superior to those wintered away.

Many experienced hill sheep farmers maintain strongly that away-wintering of ewe hoggs is to be preferred and that without it flock deterioration will be met. Usually, however, their experiences have been with wintering on the hill and not on improved grazing.

Provided that suitable areas are selected and that the mineral deficiencies in respect of lime phosphate and other materials are made good, there would appear, in the light of these experiences, to be no reason why home wintering should not be as satisfactory as away-wintering. It has, of course, to be kept in mind that some hill farms have not a sufficient area of improvable land to carry their normal ewe hogg complement, and in such cases home wintering is impossible. Other farmers also maintain that if they could improve such an area they would find it more profitable to send their hoggs away and use the better grass at home for wintering some of their ewes.

Though the need for providing better wintering has been stressed above, it is by no means the only major problem facing the hill sheep farmer. Breeding for " hardiness " and survival is of equal importance. Not every shepherd will agree that the hardiness of our hill breeds has deteriorated, but there is little doubt but that this is the fact. One important cause is the method of bringing out rams in fashionable flocks. Though the average hill farmer does not buy rams from those flocks that bring the highest prices at a few special ram sales, he is influenced by them. There is, to all intents and purposes, a pyramidal structure in ram breeding in hill breeds. At its apex are a few flocks, concentrating on turning out rams for these sales, in which the ewes are not kept under hill conditions except for a very short spell in summer. During winter, when hardiness is of first importance to a hill ewe, they are usually in enclosed fields, partially sheltered from the storms and other hardships that the true hill ewe has to experience. Their ram lambs seldom see the hill and are in fact wintered on good fare, sometimes under cover. This may have the advantage of showing fattening ability and early maturity, but it is done under conditions such as a normal hill sheep never sees and it is not a test of suitability for hill conditions. In fact it may preserve sheep definitely lacking in hardiness, unless the flock is periodically replenished by selected hardy ewes from the hill. Rams reared in these flocks do not, of course, find their way into commercial flocks, but the ram lambs from the ewes with which they are mated will in all probability do so, and in this way practices which may be profitable to the individual ram breeder, but are in the long run disastrous to the hill sheep industry, are having a progresssively insidious effect.

Allan Fraser (Ref. 4) has given figures from the records of two hirsels of commercial Blackface stock on a private farm in Argyllshire, which show that the number of ewes dropped from 998 for the years 1912-16 to 910 for the years 1926-30. Over the same period the percentage of lambs weaned remained more or less constant, dropping from 65 to 64, but the percentage of mortality amongst ewes and hoggs increased from 10 to 15. Such reduction in the ewe stock and increase in the mortality rate is quite common. Similar figures could be got from the records of many hill farms and the implied fall in output per man employed is such that, without a reversal of the process, there can be no economic future for many existing hill farms. In fact this branch of farming cannot face the increased costs and changed social demands that the war has brought in the same way that arable and dairy farming may do. The work of a hill shepherd cannot be mechanised as can that of the ploughman or the dairy cattleman. If, therefore, the increased output per man that is being secured elsewhere is to be secured on hill farms it means restoring if possible the former rates of stocking and definitely reducing the present high mortality rates. A reduction in the latter reflects a general reduction in disease and in flock troubles and a less strenuous time for the shepherds.

An interesting experience in selecting for hardiness in a Blackface flock has been desscribed by Ian E. Sandison (Ref. 5) who farms in the Island of Unst in the Shetlands. By rigid selection on the basis of ability to survive and do well, without extra assistance, on the natural herbage of the hill grazings on his farms, he reduced the mortality rate in his flock in the ten years up to 1934 by over 50%. A recent visit to this farm showed that the

process of selection on these lines has been continued since then with marked success. One great difficulty arises in securing rams known to be sufficiently hardy for the flock. In fact this is extremely difficult and new rams are tested very severely, the produce of any which themselves fail to meet the requirements being discarded. The reduced death rate in both young stock and ewes has lowered the numbers that need to be reserved each year to maintain the breeding flock and so it is possible to cull these heavily. In regard to wool and certain other features the type has altered, with advantage, to that of the hardier sheep of last century, but, as the flock is managed to secure good financial returns and the lambs are sold in the commercial market, attention is given to maintaining good body conformation. It has been a definite experience in this flock that making hardiness the first essential has reduced markedly the amount of shepherding required, even at lambing time, and has not led to any sacrifice either of prolificacy or nursing ability. In fact good milking capacity in the ewe seems to be associated with hardiness in the offspring, and well-nourished lambs stand a better chance in the survival of the fittest.

The Scottish Hill Sheep Committee's Report (Ref. 1) stated "Though no statistical data are available regarding the incidence of disease among sheep flocks in Scotland, the evidence from practically all sources emphasizes the major importance of this factor in the economic losses sustained by the hill farming industry. There is also evidence to indicate the increasing prevalence of disease in recent years. Apart from the mortality among lambs and breeding stock, widespread morbidity has contributed greatly to the lowered production of the industry and the progressive deterioration of hill flocks." It is true that much loss is caused by specific infective diseases, for some of which research institutes have already indicated satisfactory methods of treatment and for others of which investigational work is proceeding vigorously. The indications are, however, that the loss due to nutritional disorders and deficiencies and the "black" loss due to lack of hardiness amount in all to much more than that caused by what the sheep farmer normally regards as disease. Though there is already quite an accumulation of knowledge on what is necessary to improve the standards of nutrition, much research and experiment is still required to ascertain more about the grazing habits of sheep and cattle on hill grazings and to assess how far the results of research can be put into practice effectively and economically.

Further, the hill grazings of the country call for a survey in respect of their utilization. The future demand for land for afforestation will be great, and it is essential that the indiscriminate use of hill land should be avoided. Actually there are hill farms which have become so overrun with bracken that they are virtually useless for sheep grazing, while the eradication of the bracken by normal methods is impossible because of the nature of the ground. Here, in the light of existing knowledge, planting with trees is the only possible means of adequate utilization. Other farms and hirsels have become uneconomic to operate for a variety of reasons, and in many cases the capital expenditure that would be required to make them workable would be out of all proportion to their production if improved. Such should also be planted. Provided a survey is carried out by competent individuals and the afforestation is on a planned basis, there need be no antagonism between hill sheep farming and forestry. In fact the latter could operate greatly to the advantage of the former. Though the clearing of trees from the Scottish hills two hundred years ago may have made possible a Highland sheep industry, it is a pity that the clearing was so thorough, since the area has suffered ever since from the need for adequate shelter.

The importance of hill sheep farming in Scotland cannot be denied, since on it depends the whole of the lowland sheep industry, based as it is on ewe flocks composed of first-cross ewes bred from hill stock. What is required to-day is the necessary stimulus to encourage hill farmers to improve both their farms and their stock. Both aspects need to be dealt with, though the major task is to fit the sheep to the hills rather than to make the hills suit

the sheep. Whatever may be done elsewhere, in the Highlands extensive improvement of the open hill is limited in the main by factors which make it economically impossible. Nevertheless the reseeding of former arable areas, the burning of heather on a rotational basis, the maintenance of hill drains and the introduction of cattle are all feasible and until they are done deterioration will continue. Wartime experiences have shown forcibly that nothing stimulates a farmer to improved farming methods more than economically satisfactory conditions of production. At present hill sheep farming is not in a healthy or satisfactory state and none of these problems of turning hill farms into efficient production units will be widely tackled until the farmers concerned have greater grounds for looking optimistically to the future.

A. R. WANNOP.

THE NORTH OF SCOTLAND
COLLEGE OF AGRICULTURE,
ABERDEEN.

References

1. *Report of the Committee on Hill Sheep Farming in Scotland*, 1944.
2. A. S. B. WILSON, "The Improvement of Rough Hill Pasture by Cattle-grazing". *Scot. Journal of Agriculture*, Oct. 1936.
3. DUNCAN M. STEWART, "Cattle on Hill Grazings" *Scot. Journal of Agriculture*, July, 1941.
4. A. H. H. FRASER, "Economic Aspects of the Scottish Sheep Industry." *H. & A. S. Transactions*, Vol. LI. 1939.
5. IAN E. SANDISON, "Attempted Improvement of the Blackface Sheep in Zetland." *Scot. Journal of Agriculture*, Oct. 1935.

III. THE IMPROVEMENT OF IN-BYE OR ENCLOSED AREAS.

IN the final analysis there is one problem in hill farming, namely that of securing an economic return ; but there are many questions of management which vary in importance according to the district and the particular kind of hill farm concerned. On many hill farms with which the writer is familiar, the supply of hay for winter feed is of great importance. It is of special significance if cattle breeding and grazing are to be developed with consequent benefit to the quality of the rough grazings, and as is to be hoped, to the farmer's balance sheet. The principal objective should be increased output, and for hill farms this means increased sales of stock. In the main this is not likely to come from increased numbers of sheep on the hills, for nothing is easier or more fatal than overstocking with sheep, and a reduction rather than increase in numbers may on some farms make possible better results. Better control of disease, general improvement in the health and vigour of our flocks, and management which reduces to a minimum mortality in both ewes and lambs, are methods which, as they are more fully understood and applied, will help to increase output. The improvement of the enclosed fields to which this section of the study is limited has a part to play in this connection.

Not all hill farms are capable of carrying more cattle, and even on farms considered suitable for this development it must be carried out judiciously and with due regard for the seasonal requirements of the sheep. Building accommodation, especially if the young cattle are to be wintered rather than sold in the first year as weaners, and the labour required for tending cattle there are factors which must be given careful thought. Seasonal agistment of cattle is not an adequate solution to the problem of increased output on hill farms. More and better food for stock is the primary need if this increase is to be achieved.

More and Better Hay.

On many hill farms known to the writer the hay supply is inadequate, and leaves little or no reserve against a bad winter. The trials referred to later were carried out following

a succession of bad winters, which had resulted in a considerable number of deaths among sheep due largely to a shortage of hay. This survey refutes the opinion that hardiness is the product of semi-starvation. An inadequate hay supply is a factor which, in the writer's opinion, exercises over the years a serious cumulative effect on many hill farms. It is a handicap to output which is often insufficiently realised.

Any suggestion relative to the introduction or possible increase of cattle on hill farms, especially if, as in the case of a breeding herd, wintering is involved, commonly meets with the limiting factor of lack of hay or other winter feed. When the writer used to suggest the possibility of increasing the yield of hay he was commonly informed that the results of manurial trials on the hay crop in the lowlands could not be repeated on the hay fields on hill farms, and this for at least two reasons, (*a*) altitude and later seasonal growth and (*b*) late grazing due to the fields being used for lambing well into May.

In 1935 trials were commenced by the writer (Ref. 1) in collaboration with the County Agricultural Organiser in Northumberland. Three hill farms were selected and plots were laid down on two enclosed hay fields on each farm, the farms being carefully chosen for geographical situation and also to represent high, medium and low-fertility holdings. The fertilizers used were nitro-chalk and I.C.I. Concentrated Complete No. 4, at the rate of 2 cwt. and 3 cwt. per acre respectively for each of the three years, 1935-37. Weights of hay were taken for three seasons and for two years (1936-37) weighings were made from duplicate plots with the addition of certain dunged and slag-plus-potash plots.

The outstanding result of the trials was the demonstration (nothing more is implied by this word) of the response of the land to more generous manurial treatment, as is evidenced by the following results :-

QUANTITATIVE RESULTS.

TABLE 1.

Yields of Hay in Cwt. per acre.

Three Years' Average (1935-37) for Original Plots.

	Plot	*Newbiggin.* West Meadow	*Newbiggin.* 40-acre Meadow	*The Combe* Longriggs Low Area	*The Combe* Longriggs High Area	*High Shaw.* Small Meadow	*High Shaw.* Large Meadow
1.	Nitro-Chalk	50-2/3	56-⅓	37	35-2/3	36-2/3	30⅓
2.	Complete	62 2/3	53	49-2/3	39	36-2/3	40-2/3
3.	Control	46-2/3	32	34-2/3	29⅓	17	21-2/3
	Increase over Control Plot (Cwt.)						
1.	Nitro-Chalk	4	24⅓	2⅓	6⅓	19-2/3	8-2/3
2.	Complete	16	21	15	9-2/3	19-2/3	19

The figures show that, while the dressing of Nitro-Chalk produced in one case an increased yield of more than one ton per acre, there is very wide variation in the effects of this treatment—the increases ranging from less than 10% to over 100%. It should be noted that the high increases occur on the 40-acre Meadow at Newbiggin and the Small Meadow at High Shaw. These instances of high yields appear to be due to recent substantial applications of phosphatic manures to those meadows.

The Complete Fertilizer gave consistently good yields, the increases ranging from about ½ to 1 ton per acre. Again the highest increases in yields were obtained on the same two meadows mentioned in the previous paragraph. The average annual increase for the six meadows from this treatment has been 16¾ cwt. per acre, being 55% over the control.

The dunged plots limited to five of the meadows gave an average increase of 11½ cwt. per acre and the slag and potash treatment, confined to three meadows, gave very uniform increases, the average being 8 cwt. per acre. This increase compares with increases of 8 cwt. per acre for the nitro-chalk treatment, 14⅓ cwt. for the complete fertilizer treatment on the duplicate plots in the same three meadows, *i.e., for the two years' average.*

Although the results are not strictly comparable it is worthy of note that, in the well-known Cockle Park (the Northumberland County Experimental Station) meadow hay trial in Palace Leas Field the percentage increase of crop for the first three years resulting from the application of a complete fertilizer on land yielding 19 cwt. per acre when unmanured, was 43%. In the hill farm trials, using a complete fertilizer for three years, the percentage increase was 55%, an increase obtained at an altitude hundreds of feet higher than Cockle Park and from applications of fertilizer which could not be made until the fields were finally cleared of stock in May.

In addition to securing the bulk weight of hay from the different treatments it was arranged with the helpful collaboration of Mr. B. Thomas, M.Sc., A.I.C., Advisory Chemist, King's College, to obtain analyses of the different samples of hay. It was found that balanced manuring, *i.e.*, using the complete fertilizer, including nitrogen, phosphate and potash, affected a marked increase at each centre in the total production of protein, lime and phosphoric acid.

The need and value of better manurial treatment for the hay land on our hill farms is confirmed also by the results obtained from the use of farmyard manure in these hill farm trials. The dung plots received annual dressings during these trials. Most hill meadows receive dung, but the quantity per acre and intervals between dressings vary greatly and generally speaking are inadequate. Analyses were made of typical samples of the dung used on these hill farms. The figures show a comparatively low percentage of nitrogen and phosphoric acid, the potash content being helped where bracken was used for bedding. Shortage of adequate available nitrogen is no doubt a serious limiting factor in securing bulk growth on many of our hill meadows, and it was not surprising therefore that striking increases were obtained in these trials from nitro-chalk alone. There is certainly scope for increased use of nitrogen for top dressing old and new land meadows to provide hay and aftermath silage cuts. It was observed, however, that the best result from active nitrogen on these meadows was obtained where phosphates had been applied previously and fairly recently, a result which the writer has confirmed by many subsequent observations on lowland as well as on hill farms. The restriction in the use of phosphates, and especially slag, on permanent grass during the war years, means that there is now an urgent need for phosphates on hill farm meadows.

Drainage is also a matter which is in need of much fuller attention on many of our enclosed hill meadows and grazings, and there will be much to be done in open and closed drainage on our hill farms, when labour and capital are more freely available, to make the land sounder for increased production.

Lime is certainly another fundamental need of our inbye meadows, and it is pleasing to note that the lime subsidy is making some contribution to the meeting of this need; but much more is needed and, in the writer's judgment, an increase in efficient contract lime-spreading services would be helpful in overcoming present labour difficulties.

Summarised, it may be said that these trials demonstrated beyond a doubt that much improvement could be obtained in the hay crop of our hill farms by more generous and systematic manuring resulting in more and better quality winter keep. The trials concluded in the year in which the Land Fertility Act introduced the subsidies on lime and basic slag. Given confidence in the future, and capital to lay out in fertilizers, a fuller appreciation of the implied recommendations of the report might have been expected : but alas, both these factors were lacking and it was not until the outbreak of the present war that the parlous condition of our hill farms was recognised by practical (financial) measures which have assisted though they have not remedied the position.

Re-seeding.

The present war and, in particular, the Food Production Campaign, has involved the use of the plough on some hill farms for the first time in living memory, and on others to a much greater extent than was deemed necessary in the war of 1914-1918. In addition to areas ploughed up for cropping with oats, green crops, etc., some land has been ploughed for direct re-seeding. The following extract is taken from the Report on the hay trials referred to earlier, written in 1937 :—

"There is much evidence on many hill farms, including the centres at which these trials "were conducted, of the usefulness of the plough, where circumstances permit, in making "possible the production of better grass whether for hay or grazing purposes."

It is hoped that the land ploughed in recent years will be put back to *good* grass but the full repercussions on the stock of hill farms as a whole of the change to new grass are as yet unknown. That improved hay crops and better grazing, both in bulk and in respect of protein production and mineral content of the swards, will result are not doubted, but the effects on the stock carrying capacity of the farm and the nutrition of the breeding animals are, in the writer's opinion, not yet fully understood. There are hill farmers who, years ago, questioned the value of slag treatment on in-bye land for the reason that it made too wide a difference between the natural grazing of the out-bye or hill and that of the enclosed fields, with consequent deleterious effects on the ewes. If there is any truth in the ill-effects of such treatment of the in-bye land (which the writer doubts) the argument would certainly be stronger if well-manured, re-seeded land was used in the comparison. There is certainly an opinion that the hay from the re-seeded land does not give as good results on the hill farm as the hay won from such land before improvement. Time and nature may, of course, even-up to some extent any such marked differences, for the most common question asked by hill and marginal farmers concerning re-seeded land is "How long will it last ?" It would appear that, given reasonably good grazing management, it is not until 5 and 6 years old that such re-seeded land becomes intermixed with bent, Yorkshire fog, crested dogstail, etc., and assumes a closer resemblance to those old permanent swards which have been improved *without ploughing* by generous slagging and good grazing. Under poor soil conditions, poor drainage and inefficient grazing management reversion is, of course, quicker. Northumberland experience indicates that, when re-seeding very poor land, the quality of the new sward and especially its "lastingness" as a pure sward*, are much better if this seeding down is done in the second year after ploughing, *i.e.*, preceded by a "conditioning" crop. In the first year or two of the new swards there is, however, certainly a marked difference in the character and quality of the herbage as compared with the older grazing. Much-needed work at the present time is a combination of chemical analyses and feeding trials with cattle and sheep on the new and old-land hays produced and fed on hill farms. That new-land aftermaths can be very useful on a hill farm for carrying the lambs on to a later sale date and to better sale condition is true, but, in the main, the hill farm is most usefully employed in breeding rather than fattening stock, thus exploiting its natural environmental conditions for the production of vigour and constitution and capacity to make use of better food on the lowland farms. It is important therefore in adopting re-seeding on a hill farm to consider carefully its place in the evolution of a balanced hill farming policy. New leys will exist on many hill farms in the next decade by reason of the fact that wartime ploughing has been done on so many of these farms and the likelihood that most of this land will go back to grass. Re-seeded land and more hay on hill farms may make a useful contribution to the wintering of the ewe hoggs where these are not sent for the first winter to a lowland farm. Hill farmers are generally agreed on the importance of this first winter in relation to the subsequent usefulness of the hill ewe and it

*By which term is meant the long lived species sown in the original seeds mixture.

would seem that amongst the advantages gained by wintering on another farm are better nutrition and cleaner (*i.e.*, as regards sheep grazing) land. New leys once established may secure these advantages on the farm on which the sheep are bred. Some farmers have discovered or re-discovered the value of an area of arable in providing food for stock in the winter, especially for cattle, and may desire to retain some land for periodical ploughing and cropping. If it can be economically worked there is much to be said for this plan. Turnips, rape mixtures, and oats, even if the last-mentioned have to be cut on the green side to be fed unthreshed to cattle in the winter, and also silage crops have proved useful on those hill farms favourably situated for marginal or lower land cultivation.

Even when no such arable cropping is contemplated for the future—and this is largely bound up with the costs of cultivation in relation to prices and the provision of an efficient contract system—direct re-seeding will continue to spread up towards the higher altitudes. Meadows with poor, weedy swards with heavy infestation of plants like yellow rattle (*Rhinanthus crista-galli*) which are ploughable can be improved by re-seeding quicker than by any other method. The cost of this re-seeding to the farmer in Northumberland in the last few years, when done by contract. has been on an average about £12, before deduction of the grant of £2 per acre ploughing subsidy granted for approved schemes. When the re-seeding has been done by the farmer himself the cost has been about £10 10s. per acre, before deduction of the subsidy. The chief reason for hesitation in adopting direct re-seeding on many hill farms has been the lack of confidence in the future and, therefore, in regard to the possible returns from such improvement. For, as in the case of mole draining, the costs of re-seeding may vary greatly by reason of the expenditure on what may be described as subsidiary work. At one of the re-seeding demonstration centres for which the writer is responsible practically worthless fell grazing was ploughed; it had then to be fenced, watered, stoned and in part drained. Excluding the cost of fencing (£2 10s. per acre) and the drainage, the cost of re-seeding this area was about £16 10s. per acre, before deduction of the ploughing grant of £2 per acre. It will be seen, therefore, that land reclamation of this kind may involve an expenditure of £20 or more an acre, and should not be embarked on without careful consideration of the capital value of the land, the particular circumstances of the field and farm, and the probable returns.

On hill farms the securing of the return from re-seeding by grazing is not so straightforward a matter as on the dairy farm. For one thing the necessary cattle to graze the new ley in its first year (a very desirable procedure even though the field is subsequently used for hay) may have to be purchased as spring stores and sold in late summer, a financial outlay which may be considerable and often of a highly speculative nature. Nothing will spoil a new ley more than under-grazing, especially if 8-10 lb. Italian ryegrass per acre is used as the nurse crop for the seeds mixture, and cattle as well as sheep are necessary for the grazing of new leys. When rape is used as the nurse crop experience indicates that rather less than the standard 3 lb. per acre may be best—say 2 lb.—unless one can be sure that the rape will be grazed reasonably early and grazed off clean without undue delay. A dense growth of rape, stocked rather on the late side or not fully stocked, will tend to smother out the young seeds. In these days when good seeds mixtures cost £4-£5 per acre a hill farmer cannot afford a failure of the seeds.

When the land is "conditioned" by grazing a folding crop in the first year this may be a substantial aid in securing some financial return from the feeding of sheep prior to re-seeding. It is important, both for the sake of this folding crop and also that of the seeds sown in the second year after ploughing out, to pay due attention to liming and phosphates. It is therefore an advantage, especially on poor land, to apply, in addition to the other fertilizers used, 1 cwt. of sulphate of ammonia for the conditioning crop, for the better the growth of this crop the more sheep can be fed, with the consequent better manurial residue

to the land. A typical procedure after good ploughing has been the application of 30 cwt. ground limestone (form and quantity of lime governed by the pH figure of the soil test and other circumstances) disced in, followed by 3—5 cwt. superphosphate and 1 cwt. sulphate of ammonia per acre applied in preparing the seed bed, the land being worked as fine and firm as possible. The kind of mixture which has been recommended by the writer during the war, and which has proved useful under a variety of conditions is as follows :—5 lb. rape, 8 lb. Italian ryegrass and ½—1 lb. Hardy Green turnips per acre broadcast. This mixture has given results varying from 10—25 sheep fattened per acre. There are, of course, various mixtures including rape as well as other plants. The advantage of the ryegrass and turnip mixture over rape alone is in the improved palatability and longer effective feeding period. The following year the seeds should be sown after securing a tilth by discing and rolling or by ploughing, discing and rolling ; a fine consolidated seed bed is essential. The standard Cockle Park seeds mixture, 16 lb. perennial ryegrass, 8—10 lb. cocksfoot, 4 lb. Timothy, 3—4 lb. late flowering red clover, 1 lb. wild white clover, has proved very satisfactory in Northumberland at a wide range of altitudes, subject to minor modifications and using in part or in whole, special leafy strains where desired. Broadcasting by fiddle or box seems to give better results than using ordinary drills, though if the last-named are used the drilling should be done both ways. Special grass-seed drills may give good results as they are developed for more general use. Eight to ten cwt. basic slag (depending upon grade) may meet the initial needs of the young seeds. In the above mixture the timothy is sometimes omitted and in other cases the cocksfoot. The timothy seeding is increased when cocksfoot is excluded. If the seeds are not to be used for hay in the first two years the red clover is omitted and 2 lb. Alsike and white clover substituted.

Improvement without ploughing.

There are still thousands of acres of fell or " white " land which are capable of considerable improvement by intensive grazing and treading by cattle and suitable fertilization. The tradition dies hard amongst some shepherds of the need for abundant strong growth of grass for the ewes. On examination of white land such as is typical on the Cheviots it is found that, of the 1½—2 acres of grazing allowed for a ewe, rather less than one-third is effectively grazed, though it is, of course, true that the poor nature of much of the herbage necessitates a wide range for the animal to enable it to secure adequate nutriment. Nevertheless by grazing off much of this roughness, reducing the mat by treading, pitch-poling, and by slagging or liming or both, useful grazing for cattle and better ultimate grazing for the sheep can be attained. For this kind of improvement fencing into reasonably sized enclosures (40—60 acres, given sufficient cattle, is the maximum preferred by the writer) is a necessary first step, and the all-important matter of access to an adequate drinking water supply must receive like consideration. More use might be made of the electric* or other similar temporary fence in carrying out this kind of improvement for smaller areas. Improvement by enclosures of this kind are in the writer's judgment to be preferred to slagging random small areas on the unenclosed hill to form "oases" of clover and mineral richer herbage. Nearly a quarter of a century ago the writer had experience of this plan, advocated later by Sir R. G. Stapledon in his book " The Land Now and Tomorrow," on hill grazing situated at Otterburn. The result was an excessive concentration of the sheep on these more closely grazed patches, which tended to justify the shepherd's criticism of aggravating parasitic and other sheep troubles. Tackling a defined, enclosed area which can be cleared entirely of stock for rest periods, however short, is another matter, and may prove indeed a very useful treatment for some years in anticipation at a later

*The risk of fire on some areas is not negligible and there is scope for the provision of new types of cheaper and efficient fencing for hill enclosures.

stage of ploughing out and re-seeding if thought desirable. On such reasonably sized areas renovating or regenerating mixtures of a cheaper kind may be used as part of what may be described as a reclamation process.

The improvement of the mineral composition of open grazings by mineral manuring *on an extensive scale* is a problem which awaits solution. Inaccessibility, cost of distribution of fertilizers and other difficult circumstances may possibly find solutions in post-war years by the use of aeroplanes for distribution of manures. The grazing management, especially on the white land, is, however, very important and for *even grazing* necessitates reasonably sized areas. So far as the heather is concerned it is agreed that this plant is a most valuable constituent of hill sheep grazing, and certainly susceptible to improvement by systematic burning. Bracken, which spreads down the hill and has infested many enclosed grazing areas, can be eradicated by systematic cutting or cattle grazing and treading, the latter being encouraged when circumstances justify the application of fertilizers.

Fertilization of hill grazing simply by extensive distribution is an extremely doubtful method of meeting the evident decline in mineral resources of many of our hill grazings. Yet in general it is true to say that there has been gradual but very definite deterioration in our hill grazings, and improvement in mineral content is an urgent need. Recent work by another of my colleagues, Dr. Milne (Ref. 2) reported at the Conference on Hill Farming in the Northern Counties held at King's College, Newcastle-upon-Tyne, indicates that the tick problem is very largely a symptom of hill-land deterioration, and the writer has reason to believe also from personal observations in Northumberland that proper burning of the heather is also an effective measure against the ravages of the heather beetle. Dr. Milne's conclusion is that hill grazing improvement should ultimately result in a substantial reduction in ticks, and he cites the claim of several farmers to have brought about this most desirable reduction by mixed grazing, bracken eradication, burning, draining and harrowing, etc. Such improvement would be beneficial to both sheep and cattle grazed on tick-infested hills, and a beginning should be made on the enclosed areas working up to the hill.

It is evident to anyone familiar with our hill farms that such improvement could be obtained with our present knowledge given the will, the resources and confidence in the future, and that on existing grazings which are not or cannot be ploughed, more systematic burning of heather and control of bracken, the increase and improvement of fenced enclosures, and more generous mineral manuring of existing enclosed areas, together with improvement of drainage, would produce more and better food for stock on hill farms and ultimately greater output. Re-seeding has its place in the improvement of hill farms but, in the opinion of the writer, there are many enclosures of unimproved rough grazings which when phosphates are available for this purpose can be more economically and efficiently improved by slagging, pitch-poling and systematic mixed stock grazing, according to the traditional Cockle Park method.

H. CECIL PAWSON.

KING'S COLLEGE,
NEWCASTLE-UPON-TYNE.

References.

1. PAWSON, H. C. AND MURCHIE, A. "The Meadow Hay Crop." Report of Trials in Northumberland.
2. Report of Hill Farming in the Northern Counties, Dept. of Agriculture, King's College, Newcastle-upon-Tyne.

THE NEW INSECTICIDES D.D.T. AND BENZENE HEXACHLORIDE AND THEIR SIGNIFICANCE IN AGRICULTURE

INTRODUCTION.

BY one of those coincidences that seem unaccountable in terms of pure chance, two of the most remarkable insecticides ever to be discovered came to light about the beginning of the present decade. These were the materials now widely known as D.D.T and as benzene hexachloride, 666, or Gammexane. The coincidence extends further in that each substance was discovered very many years before its insecticidal properties became apparent. Nor does the resemblance end there, for the two substances share the distinction of being the first examples of a new class of insecticides. All insecticides act either by contact with the external surfaces of the insect or by being ingested. Until the new discoveries, the former group—the contact poisons—comprised more or less evanescent materials like nicotine, which is volatile, and pyrethrum, which is chemically unstable. Conversely the 'permanent' insecticides like lead arsenate and Paris green were all stomach poisons with little or no contact activity. The unique characteristic of D.D.T. and benzene hexachloride is that they combine contact activity with a stability and persistence that confer protective properties. They are, moreover, powerful stomach poisons as well, and benzene hexachloride can act also as a fumigant. Because they embody this novel combination, the introduction of these new insecticides has opened up entirely new possibilities in pest control.

The conjunction of outstanding properties with the mystery in which official policy shrouded these products has provided an opportunity for sensational accounts rarely equalled in pseudo-scientific journalism. D.D.T., in particular, has had thrust upon it a publicity as unwelcome as it has been, in the main, inaccurate, with the inevitable result that the 'man in the street,' according to the measure of his cynicism or credulity, has come to regard it either as just one more quack remedy or as a near-miracle that will solve most of the world's outstanding problems. Furthermore, a partisan element has been introduced into the 'news' with the result that the two materials have often been represented as rival contestants for a common field of application. In fact, there is already evidence that while they do have some most important properties in common, they yet differ sufficiently in their specific toxicity and precise mode of action to give to each its own distinctive uses.

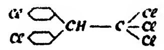
The course of the development of these two insecticides has been very dissimilar, largely because of the very different background of their introduction. Although the output of D.D.T. has been strictly controlled to meet the needs of the services, limited amounts have been widely available for experiments. Benzene hexachloride, on the other hand, has not been accessible to research workers and most of the trials with it have been carried out by the manufacturers. This position is reflected in the amount of published work that has resulted. Although much important work on D.D.T. remains unpublished, a large amount is already available, whereas only a few papers on benzene hexachloride have yet appeared. Because of this it would be misleading to attempt to discuss the two substances side by side in respect of any particular pest, and accordingly they will be considered separately in this review.

One other element of the situation, again most pressing in the case of D.D.T., calls for mention. There is abundant evidence that the aforementioned publicity will be

exploited to the full by the less scrupulous and more ephemeral manufacturers of insecticides. Because of this it is highly desirable that these products should be brought as soon as possible within the Approval Scheme of the Ministry of Agriculture so that whoever would avail himself of the protection this Scheme affords may do so. This is all the more important since, for reasons to be discussed later, these materials will need to be used in agriculture and horticulture with the greatest circumspection.

D.D.T.

Following the appearance of many ill-informed and some completely erroneous versions of the history of D.D.T., detailed and authentic accounts have now been published (Refs. 1, 2, 3). Only the salient points, therefore, need be recapitulated here.

Early in 1942, a series of papers by Wiesmann, of Wadenswil Experiment Station, Switzerland, appeared in the journal *Schweizerische Zeitschrift für Obst- und Weinbau* describing exploratory trials with several new, synthetic, organic insecticides. Among these, and most promising of them, was a proprietary product "Gesarol" made by the firm J. R. Geigy A.-G., of Basle. These communications, though recognized now as the first open indications of a revolutionary discovery, attracted little attention at the time, partly because the journal was little-known in Britain, and partly because no indication was given of the nature of the insecticidal principle of the material. Not until the end of 1942 was information received in this country that identified the substance $\alpha\alpha$-bis (4-chlorophenyl)-$\beta\beta\beta$-trichloroethane (Ref. 4)  as the active ingredient of Gesarol. By this time, however, the veil of official secrecy was tightly drawn and only a few were allowed to know that a new star was rising in the firmament.

The substance itself, alternatively known as 4-4′-**D**ichloro-**D**iphenyl-**T**richloroethane (whence D.D.T.) was prepared and characterized as a chemical individual by Zeidler in 1874, but its biological activity seems to have passed unnoticed until discovered in the Geigy laboratories about 1937 (Ref. 5). Läuger, Martin and Müller (Ref. 1; this important paper has been extensively summarized in English by Campbell and West, Ref. 6) have described the lengthy investigations which, by a painstaking and systematic application of the established principles of dyestuffs chemistry and pharmacology, led eventually to the recognition of the outstanding toxicity of D.D.T.

In normal times the new insecticide would no doubt have come slowly to general acceptance by the usual stages of trial, development, and large-scale use. But 1939-40 saw the closing of all the normal channels of communication with the Continent and no intimation of these discoveries reached this country for several years. By the time D.D.T. was brought to the notice of the British and American authorities late in 1942, the insecticide position had become one of acute difficulty, for supplies of derris and pyrethrum were very low and quite inadequate to meet service requirements. In consequence D.D.T. was taken up and its potentialities in relation to military needs explored with unexampled speed and energy. The resulting unqualified success against disease-carrying insects, especially mosquitoes and body lice, is an often-told story (*e.g.* Ref. 3) that need not be repeated here. It is sufficient to quote the view that D.D.T. has probably been a major factor in the success of several allied military campaigns. While it is no part of the purpose of this review to deal with non-agricultural applications of D.D.T., it may be said in passing that striking success has been achieved against such diverse pests as house-flies, cockroaches, lice, bed bugs, mosquitoes, tse-tse flies, and locusts.

Inevitably in these circumstances service demands called for the maximum possible output and only small quantities were released for experiments on the control of insect pests in agriculture. Not until late in 1945 was there a partial release of D.D.T. for general use

in commercial products. Nevertheless, an extensive exploration of the potentialities has been possible and an impressive amount of information has been accumulated.

In the synthesis of the chemical a mixture of isomers and side-products results in which the so-called *para-para'* (*p-p'*) compound predominates. In many of the earlier batches made under pressure of war-time demands, the content of this isomer was as low as 50 per cent., but in the better products of to-day it consistently reaches 80 per cent. or more. To avoid confusion the term 'D.D.T.' should be applied only to the commercial product, whereas the pure *para-para'* compound should be designated by its full name. Martin, Stringer and Wain (Ref. 7), Martin and Wain (Ref. 8). and other workers have examined some of the individual components of the mixed product D.D.T. and have shown that while several of them possess insecticidal properties, their combined activity is relatively small in comparison with that of the *para-para'* body. The relation is somewhat analogous to that of the non-rotenone ether extractives to rotenone in derris root.

Most of the Swiss work has utilized proprietary forms of D.D.T. under the names Gesarol and Gesapon. The British-made equivalents of these are Guesarol and Guesapon and all these preparations normally contain 5 per cent. of D.D.T. G(u)esarol contains D.D.T. mixed with an inert diluent in a form suitable for dusting or, with wetting and suspending agents included, for spraying. G(u)esapon is an emulsified form of a solution of D.D.T. in an organic solvent, usually benzene, xylene, or solvent naphtha. These, however, are only some of the possible types of D.D.T. preparation. These types may be classified as dusts, dispersible powders or pastes, solutions giving dispersions on dilution with water, preparations of the miscible oil or stock emulsion type, and straight solutions for atomization.

A particularly interesting variant of the last named is the 'aerosol' type of preparation. Aerosols consist of particles so finely dispersed in air that they have little or no tendency to separate out. Smoke, for example, is an aerosol in which the dispersed solid consists of minute particles of carbon. As a means of applying insecticides they have been developed in the United States, mainly by Goodhue and co-workers of the Bureau of Entomology's Insecticides Division. A solution of the insecticide in a liquified gas such as the refrigerant Freon (dichlorodifluoromethane) is filled into a pressure container or 'bomb.' On opening the valve a fine spray of the solution is ejected under the pressure of the evaporating liquid, and rapid vaporization of the low-boiling solvent leaves the insecticide dispersed as an aerosol. This method of application has obvious attractions for use in glasshouses or, in conjunction with a canopy or drag sheet, on certain ground crops in the open.

The Ministry of Supply has carried out large-scale experiments on the production of smokes containing D.D.T. Details of these tests have so far been withheld, but it is understood that they have shown this method of utilization to be quite practicable. Cohen (Ref. 9) has described interesting results with smokes produced by burning impregnated filter paper.

The physical properties of D.D.T. are such that correct formulation presents unusual difficulties. Whichever method of compounding is used it is likely to be accomplished successfully only in experienced hands.

Investigations to date suggest that D.D.T. is of all insecticides one of the most widely compatible with other pest and disease control materials. Fleck and Haller (Ref. 10), however, found that nicotine and certain metallic bases and chlorides promoted decomposition of D.D.T. at elevated temperatures. China clay, fuller's earth, bentonite, and some samples of talc had a similar effect, probably by reason of the presence of small amounts of active catalysts, and such substances may have a deleterious effect on D.D.T. preparations stored over a lengthy period of time.

According to West and Campbell (Ref. 5), the first successful application of D.D.T. in

the field was the control of an outbreak of Colorado Beetle in Switzerland in 1939. It was, however, the work of Wiesmann published during 1942 and 1943 that first demonstrated the activity of D.D.T. preparations against a very wide range of agricultural pests. His experiments were mostly small-scale exploratory tests and not all his observations have been confirmed in detail, but they provided the stimulus for the vast programme of work that followed.

The outstanding feature of D.D.T. is its intense activity as a contact poison, extremely small doses and short periods of contact being fatal to susceptible insects. Läuger *et al.* (Ref. 1) calculated that on glass a deposit of one billionth of a gram per square centimetre (equal to approximately 1 oz. per 1,000 square miles) is fatal to houseflies. Wright and Ashby (Ref. 11) have shown that contact for one minute with D.D.T. is fatal to the Carrot Fly (*Psila rosae*), though death may not occur for six hours or more. Similarly Cragg (Ref. 12) has reported intense contact activity against the Sheep Blowfly (*Lucilia sericata*). In all these examples the poison appears to be absorbed through the feet or legs.

It has been stated (Ref. 1) that insects once affected by D.D.T., no matter how slightly, never recover and inevitably die. Schneider (Ref. 13) examined this assertion critically and showed that while it is true of houseflies, certain hover flies recovered apparently quite completely even from repeated doses of D.D.T., each of which had produced characteristic convulsions. This observation may have important practical significance since this kind of differential reaction may enable some beneficial insects to survive a dosage of insecticide sufficient to control some pests.

In comparison with other contact poisons, especially with pyrethrum, D.D.T. is very slow in its action; several days may elapse between contact and death. Already, however, there are several examples which indicate that although death is long-delayed, interference with vital biological processes may be rapid. Thus the successful control of Apple Blossom Weevil seems to depend largely upon the inability of the insect, though still alive and active, to lay its full complement of eggs after contact with D.D.T. Cragg (Ref. 12) has pointed out that the Sheep Blowfly does not lay complete batches of eggs after contact, and Bushland *et al.* (Ref. 14) have reported that affected body lice soon cease to feed.

The behaviour of flies poisoned by D.D.T. is characterized by a period of intensified activity in which movement is noticeably erratic. This is followed by a gradual loss of co-ordination usually ending with the fly passive on its back. Death follows some time later. Martin *et al.* (Ref. 7) have commented on the way in which certain Lepidopterous larvae (caterpillars) affected by D.D.T. pass through a phase of exaggerated and unco-ordinated movement and lose body fluids to the extent of the greater part of their body weight.

The precise mechanism of the action of D.D.T. is not yet clearly understood beyond the fact that the contact activity is exerted through the nerve centres. Läuger *et al.* (Ref. 1) have advanced the view that the $-\mathrm{C}{\leqslant}\begin{smallmatrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{smallmatrix}$ group serves as the fat-soluble 'carrier' by which the toxic *p*-chlorophenyl groups gain access to the nerve-endings. Martin and Wain (Ref. 15), on the other hand, believe that the fat-soluble 'carrier' part of the molecule is the *p*-chlorophenyl groups and that the toxic action rests upon the ability of the $>\mathrm{CH}-\mathrm{C}{\leqslant}\begin{smallmatrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{smallmatrix}$ fragment to lose hydrogen chloride. Other workers (*e.g.* Refs. 16 and 17) consider this latter view to be an over-simplification, but Martin and Wain (Ref. 8) have adduced supporting evidence in the behaviour of certain other compounds where insecticidal activity has been correlated with the facility with which the substance can lose hydrogen chloride.

All the available evidence indicates that the egg-killing power of D.D.T. is so low as to be without practical importance.

One after another so many insects were found susceptible to the action of D.D.T. that this substance was soon on the way to being regarded as a certain cure for every ill attributable to an insect pest. But greater experience and a more restrained and critical approach have somewhat modified the picture.

The insects most susceptible to the action of D.D.T. appear to be certain flies, adults of the order *Diptera*, of which several examples have already been quoted. Many Lepidopterous larvae also, notably the cabbage caterpillars, are very susceptible, but here it is difficult to assess the relative importance of contact and stomach-poison effects.

On the other hand, aphides in general have proved somewhat resistant. This may be due to the fact that there is time for parthenogenetic reproduction to take place before the parent insect dies, and while some of the young will in turn be killed, many may escape to found new colonies. Much will depend upon the density of the insect population and the rate at which new, clean, plant growth is being produced.

Outside the orders of the true insects only a few instances of marked toxicity have so far been reported. Martin *et al.* (Ref. 7) have found woodlice (*Armadillidium* sp.) to be very susceptible, as are several of the ticks that infest animals and plants. Most of the *Acarina* (spiders, ticks, etc.) on the other hand, are resistant, perhaps the most important example being the Fruit Tree Red Spider (*Oligonychus ulmi*) which seems to be quite immune. There have been numerous reports that slugs also are unaffected, but there is some uncertainty about the status of the earthworm. Wiesmann (Ref. 18) states that Gesarol is harmless to worms, but there is evidence to the contrary from preliminary experiments in this country.

Thus, despite the large number of susceptible species, it is clear that D.D.T. is by no means the universal insecticide that popular accounts have made it appear. The United States Department of Agriculture has recently stated (Ref. 19) that against a wide variety of insect species it proved better than the usual insecticide in rather less than half the cases.

Nevertheless, the widespread toxicity of D.D.T. has itself given rise to major problems. It was soon observed that large numbers of beneficial insects, notably the large group of Hymenopterous parasites, were falling victims to its action, and fears have been expressed about the consequences that may ensue. Wright and Ashby (Ref. 11) found that after spraying the foliage of carrots with an emulsion containing 0.5 per cent. D.D.T., the only insects remaining apparently unaffected in the area under observation were springtails. Among the beneficial insects killed were predaceous ladybirds and Braconid and Syrphid parasites. In the United States, *Aphelinus mali*, the parasite of Woolly Aphis, was found to be particularly sensitive, as were several predators of the Fruit Tree Red Spider. Steiner, Arnold and Summerland (Ref. 20) report a rapid increase in Red Spider following a mid-summer application of D.D.T. for the control of Codling Moth.

As was to be expected, particular fears have arisen about the effect on bees. On this point, as on several others, Wiesmann's earlier pronouncements were highly optimistic, but not entirely correct. He stated (Ref. 21) that Gesarol was entirely harmless as a stomach poison to bees and, in a later paper (Ref. 22), that Gesarol (equivalent to 0.05 per cent. D.D.T.) was toxic as a contact poison only when sprayed or dusted directly on to bees. The position has been re-examined by several American workers (Refs. 23, 24, 25) who are agreed that D.D.T. is toxic to bees both as stomach and contact poison, and, contrary to Wiesmann, they maintain that the former action is the more pronounced. Most of these experiments were of a very drastic nature and high mortality usually resulted. According to Eckert (Ref. 25), where the conditions approximated to those likely to be met in practice, it did not appear that the situation was any worse than where large quantities of arsenicals are used. It is evident, however, that excessive or indiscriminate use of D.D.T. is likely to have a serious effect on bees and that precautions, no less than in the case of arsenicals, are essential.

These considerations must serve to emphasize the caution that is essential in framing

recommendations for the use of D.D.T., but it would be unfortunate if they had an unduly restrictive effect. Final judgments can come only from widespread use in practice and such experience is not yet available in this country. In Switzerland, however, Gesarol preparations have been recommended for commercial use for several years and Schneider (Ref. 26) has recently reviewed the experience gained. The sharp increase in Red Spider has been observed following the use of D.D.T. to control Codling Moth. On the other hand, he reports that the fears of serious damage to bees have not been realized. At a joint conference (Ref. 27) of research workers, fruit-growers, and bee-keepers, held in Switzerland, it was agreed that the large-scale use of Gesarol might be continued provided that precautions were taken to avoid spraying trees in bloom.

It is now evident that the persistence of D.D.T. on plants under field conditions has been over-estimated, for many workers (*e.g.* Refs. 28, 29) report that the toxicity of treated foliage appears to fall off after periods up to 15-20 days ; even the heavy dosages applied by Wright and Ashby (Ref. 11) did not remain toxic for much more than 3 weeks. The normal growth of the plant, with the production of clean surfaces and the attenuation of deposits, is obviously a factor, but there is evidence of actual loss of toxicity in the deposit itself. Several examples are known where, under tropical conditions, foliage has become almost non-toxic within little more than 24 hours of being treated. It has been suggested in explanation of this phenomenon that the toxic substance may be inactivated by solution in the plant waxes on the leaves or may be rendered unavailable by occlusion in the wax as it is secreted. If solution plays a substantial part in the inactivation, deposits consisting of D.D.T. extended upon an inert diluent may prove to be more resistant than thin films of D.D.T. itself. Gunther (Ref. 28) and Du Pont (Ref. 29) have suggested that light of certain wave-lengths may facilitate the breakdown of D.D.T.

On balance the relative shortness of the period during which treated plants remain toxic to insects may be an advantage rather than otherwise. While the control of pests like Codling Moth (where protection is required over a lengthy period) may be prejudiced or made more difficult, there will be less cause to fear that wholesale destruction of beneficial insects will continue long after treatment.

In the United States, where the treatment of very large areas by spraying or dusting from aeroplanes is contemplated, concern has been expressed about the possible long-term effect upon wildlife in general. Although Wiesmann (Ref. 18) stated that Gesarol was harmless to fishes, it has since been shown that D.D.T. preparations are highly toxic to many cold-blooded vertebrates including frogs and snakes, as well as fishes. It is alleged, too, that large numbers of birds have been killed, possibly by eating poisoned insects. Again this is a problem whose answer is to be found only in practical experience on a large scale.

All these unanswered questions should stand as no more than warning signposts. They are evidence that neither the reckless enthusiasm nor the unqualified condemnation that some popular writers have displayed is justified.

Yet another of the problems associated with the use of D.D.T. is that of its effect on warm-blooded animals and especially humans. There has been a deep cleavage of opinion among American toxicologists, but the majority seem now to be convinced that there need be no misgivings arising from normal use. There is also the evidence that millions of service and civilian personnel have been in prolonged contact with D.D.T. in treated garments without a single known case of ill-effect. Cameron and Burgess (Ref. 30) are of the opinion that sprays containing up to 0.5 per cent. could have serious effects only as a result of grossly careless handling. On the other hand, they are insistent that precautions are essential in handling higher concentrations, especially oily solutions. Wigglesworth (Ref. 31) has reported a case of nervous derangement following drastic and deliberate exposure,

but even here the effect was transitory. There are, perhaps, two directions in which present information is inadequate. These are on the cumulative effect of small doses such as might arise in spray residues, and the effect of exposure to solutions of D.D.T. in oil, such as might be encountered in certain spray combinations. Excluding gross negligence neither of these is likely to prove serious, but the United States Department of Agriculture (Ref. 32) has provisionally fixed 7 mg. per Kg. (0.05 grain per pound) as the level beyond which D.D.T. residues should not rise.

Experience of the use of D.D.T. against a very wide variety of plant species indicates that at concentrations likely to be used in practice it is singularly free from phytotoxic properties. Here and there cases of minor damage have been reported, but, excluding instances where the damage is attributable to auxiliary materials, serious damage has been confirmed only within a single family, namely the *Cucurbitaceae*, *e.g.* cucumber.

Agricultural Applications.

It must be emphasized once again that D.D.T. has not yet been used in Britain on anything but an experimental scale. Trials have, however, been carried out against a very large number of pests and only a small proportion can be mentioned in this review. A few that appear to be of particular significance have been selected for consideration in some detail. For convenience they are grouped as agricultural, horticultural, and farm animal pests.

Flea Beetles (*Phyllotreta* spp.). In a catalogue of successful uses of Gesarol Kotte (Ref. 33) mentioned flea beetles. There was, however, little acceptable evidence to verify this claim and in 1944 the Conference of Advisory Entomologists arranged a series of field trials in which D.D.T., benzene hexachloride, and basic slag were included. The results generally showed that a 5 per cent. D.D.T. dust gave promising though somewhat variable results. Only one of these trials has yet been reported in detail (Miles, Ref. 34). A dust of unspecified composition, but presumably containing 5 per cent. D.D.T., was applied to *Brassica* seedlings at the rate of about 28 lb. per acre. The plots were first treated as soon as the seedlings appeared in quantity and before attack by the beetles began; some plots received a second dusting after a short interval. Differences between treated and untreated plots were evident after twenty-four hours, there were 10 per cent. fewer plants on the latter and the proportions of undamaged seedlings were respectively 59 per cent. and 24 per cent. There appeared to be no advantage from the second dusting and the single treatment was considered to have given adequate protection. Further field trials carried out by the Advisory Entomologists in 1945 in general confirmed that a 5 per cent. D.D.T. dust gives a good control of flea beetles on *Brassica* crops.

In laboratory tests Johansson (Ref. 35) got his best results with a mixture of Gesarol dust (5 per cent. D.D.T.) and naphthalene, but according to Fleck and Haller (Ref. 10) naphthalene may promote catalytic decomposition of the D.D.T.

Cabbage Caterpillars. Little detailed work has yet been published on this subject, but almost without exception trials have shown a very high degree of control of the Large and the Small Cabbage White Butterfly (*Pieris brassicae* and *P. rapae*), the Cabbage Moth (*Mamestra brassicae*), and the Diamond Black Moth (*Plutella maculipennis*). Martin *et al.* (Ref. 7) used the first three species as test insects in laboratory experiments and demonstrated their susceptibility to the stomach poison action of D.D.T. In the field 5 per cent. dusts and 0.1 per cent. or 0.2 per cent. sprays (dispersed solid) have given uniformly successful results Smith and Harrison (Ref. 36) found that a 10 per cent. D.D.T. dust was superior to all other insecticides tried. Apple (Ref. 37) reported excellent results with a 3 per cent. dust; and even a 1 per cent. dust, if made up by impregnation of the carrier with a solution of D.D.T., was commercially satisfactory. Bruce and Tauber (Ref. 38) also found a 1 per

cent. dust effective. This last observation is important in suggesting that it may be possible to use concentrations low enough to be relatively innocuous to certain parasites and still effective against the caterpillars. Many observers have reported that some Syrphid larvae survive treatment with D.D.T. aerosols and with dusts containing up to 10 per cent. D.D.T. (*cf.*p. 207, Ref. 13).

Carrot Fly (*Psila rosae*). Wiesmann (Ref. 39) found that the first-generation attack was reduced to negligible proportions by a single application of as little as 0.2 per cent. Gesapon (0.01 per cent. D.D.T.) within ten days of the start of emergence of the flies. A double treatment seven and twenty-one days later gave little or no control even at 2.0 per cent. Gesapon (0.1 per cent. D.D.T.). All treatments were applied to the soil at about ¾ gallon per square yard, the attack being concentrated upon the larval stage, and it is suggested that by the time of the later applications the larvae had penetrated sufficiently deeply not to be reached even by this emulsion preparation. The second-generation attack was much more difficult to deal with, but effective control followed the application of a 2.0 per cent. Gesapon (0.1 per cent. D.D.T.) either at the beginning of the flight period or fourteen days later. Lower concentrations of Gesapon and all concentrations of Gesarol (up to 0.1 per cent. D.D.T. as dispersed solid) were ineffective. It is suggested that the solid active material in the latter preparation was filtered out on the surface of the soil and never reached the larvae. The lower concentrations of Gesapon appeared not to be sufficiently persistent.

Wright and Ashby (Ref. 11) set out to check these observations under East Anglian conditions. In their trials 1 per cent. and 4 per cent. Guesapon emulsions (0.05 per cent. and 0.2 per cent. D.D.T.) were watered on to the soil, and the higher concentration gave fairly good control. The amount of liquid used, 3,560 gallons per acre, was, however, considered excessive and in further trials 1,250 gallons per acre of 4 per cent. emulsion was watered along the rows only. Again a moderate degree of control resulted, but it was observed that on plots where the foliage also had been treated the results were very much better. The explanation of this became clear when the workers learned that D.D.T. was the active ingredient of Guesapon, for laboratory experiments had revealed the toxicity of D.D.T. in xylol emulsion to adult Carrot Flies. The flies were caged at various intervals with carrot foliage after it had been sprayed with 1 per cent. D.D.T. Up to twenty-six days after treatment all flies were killed in twenty-four hours and only after thirty-three days was there marked decrease in toxicity. Counts after six hours exposure, however, showed that toxicity was falling off slowly right from the time of application. The toxicity persisted through two weeks of exposure to bright sunlight and high temperatures followed by one week of heavy rain ; dead foliage was still toxic. The deposit from a 0.5 per cent. D.D.T. spray was only slightly less persistent and slower in action. These observations were fully confirmed in field plot trials.

Finally the authors describe a large-scale field trial designed as a practical test of D.D.T. against second-generation Carrot Fly following a heavy first-generation attack. Plots were sprayed on 15th September at about 50 gallons per acre with 0.5 per cent. D.D.T. in an emulsion of solvent naphtha. There was a high mortality of the flies on treated plots, and other insects killed included capsids and caterpillars. In the treated plots 44 per cent. of the roots were undamaged and none was unsaleable, whereas in untreated plots only 16 per cent. were undamaged and 33 per cent. were unsaleable.

The authors conclude that 0.5—1 per cent. D.D.T. applied as a foliage spray against the Carrot Fly is likely to prove far superior to the sodium fluoride-molasses mixtures in current use as bait sprays. The number of applications necessary to give protection over a full season remains still to be determined.

Morrison, Mote and Rasmussen (Ref. 40) found that a 3 per cent. D.D.T. dust greatly reduced the number of damaged roots when applied as a seed treatment along the drills or dusted on to the young seedlings.

Among the most conflicting results so far obtained with D.D.T. preparations are those against the **Cabbage Root Flies** and other soil insects. In reports of early Swiss experiments (Ref. 39) it is claimed that either 1 per cent. Gesarol or 1 per cent. Gesapon (0.05 per cent. D.D.T.), watered around the plants about a week after planting out, gave perfect control of root-fly larvae. Very variable results have been obtained on repeating these trials in this country, but on the whole D.D.T. emulsions have shown more promise than suspensions. Pre-planting treatments such as puddling in a D.D.T. paste or dipping in an emulsion have been found rather more satisfactory on a garden scale.

The same reports of Swiss work (Ref. 39) state that a high degree of control of **Wireworms** followed treatment of the soil with 2 per cent. Gesarol (0.1 per cent. D.D.T.) and, possibly, by lower concentrations of Gesapon. These claims, again, have not yet found confirmation in Britain, where variable results have been obtained.

This same concentration of Gesarol, applied at about 2 gallons per quare yard, was said to be very promising against the **Onion Eelworm** (*Anguillulina dipsaci*) and also against the **Onion Fly** (*Delia antiqua*), but on the whole results against the latter in this country have not been promising.

Thus, as in the case of other soil insecticides, very much more work is required before the status of D.D.T. in relation to the control of soil pests can be assessed.

Potato Insects. The successful control of **Colorado Potato Beetle** (*Leptinotarsa decemlineata*), in Switzerland, is not of immediate practical interest in Britain, but the effect of D.D.T. on potato insects in general raises interesting possibilities. One of the greatest problems of the grower of potatoes for seed is the complex of virus diseases transmitted by insects, and the possibility of eliminating or substantially reducing these insects is attractive. American workers (Refs. 38, 41, 42) have obtained very good control of leaf-hoppers, fleabeetles, and aphides on potato by means of dusts containing as little as 3 per cent. of D.D.T.

Among other pests of agricultural crops against which D.D.T. has shown great promise are **Pea** and **Bean Weevils** (*Sitona* spp.), **Pollen Beetles** (*Meligethes* spp.) and **Leatherjackets** (*Tipula* spp.). Preliminary results against **Pea Moth** (*Cydia nigricana*) have been encouraging.

Aphides. As stated earlier, results in general against aphides have been poor, but there are exceptions such as the **Green Peach Aphis** (*Myzus persicae*) and the **Potato Aphis** (*Macrosiphum solanifolii*) (*e.g.* Refs. 38, 42). Weigel (Ref. 43) found that an aerosol containing 2 per cent. D.D.T. in methyl chloride gave far better results against *Myzus persicae* than did either a 0.025 per cent. spray or a 3 per cent. dust, and Goodhue *et al.* (Refs. 44, 45, 46, 47) showed that many species on a wide variety of plants were susceptible to D.D.T. in aerosols. It was noticed (Ref. 47) that although *Myzus persicae* on weeds showed little effect immediately after treatment, the aphides disappeared during the ensuing three weeks. Unpublished work at Long Ashton Research Station has demonstrated a similar behaviour on the part of the **Rosy Apple Aphis** (*Anuraphis roseus*) on apple. Although the individual insects appeared to be substantially unaffected, the colonies did not develop and the attack was in fact checked.

It is evident that the question of the reaction of aphid species to D.D.T. calls for re-examination in detail from both the physical and physiological standpoints.

Apple Blossom Weevil (*Anthonomus pomorum*). One of the most intractable problems confronting the fruitgrower has long been the control of the Apple Blossom Weevil. Dusting with derris, in conjunction with trapping in sack or cardboard bands, has been the best control measure available, but this has never been more than partially effective. The 'protective-contact' action of D.D.T. suggested a new approach. Wiesmann (Ref. 18) placed newly emerged weevils on cut shoots of apple that had been sprayed with Gesarol and found that they showed signs of paralysis within a few hours and died within two days.

In a small field trial weevils were placed in sleeves on branches treated with 1 per cent. Gesarol (0.05 per cent. D.D.T.); after eight days all the weevils were dead and none of the blossoms on the treated branches was capped. Wiesmann states that in a large-scale demonstration trial by the firm of R. Maag, Apple Blossom Weevil was successfully controlled by spraying with 1 per cent. Gesarol.

Both the laboratory and field results have been fully confirmed under English conditions. Dicker (Ref. 9) has shown in laboratory tests that a kill of over 90 per cent. resulted when weevils were placed on foliage treated with a 5 per cent. dust. The action was slow and deaths occurred up to the fifth day. Successful control in the field was achieved by dusting trees at Bud Burst and once or twice afterwards at weekly intervals. Chambers and Hey (Ref. 48), using a wash of unstated D.D.T. content, obtained good results by spraying twice, about Bud Burst and again just before Green Cluster. A third application at Green Cluster did not improve control and a single spraying at this stage did not give any control. Cole and Heeley (Ref. 49) compared a 5 per cent. D.D.T. dust with a spray giving about the same amount of D.D.T. per acre. In these trials the control following dusting was relatively poor, whereas the results from spraying were excellent. Edmonton and Vining (Ref. 50) obtained a 78 per cent. reduction of a heavy infestation on bush trees, and a 93 per cent. reduction of a lighter one on cordons, by spraying at Bud Burst with 0.1 per cent. D.D.T. In several of these sprays lime-sulphur was included without deleterious effect.

It is evident that there are the best of reasons for believing that D.D.T. either as dust or spray will soon become established as a routine control measure for Apple Blossom Weevil; spraying is now officially recommended in Switzerland (Schneider, Ref. 26). Correct timing is the key to success, and the first application should be made as soon as possible after Bud Burst. Whether or not it can be made earlier has not yet been determined, but serious attention must be given to the possibility of including D.D.T. in a winter petroleum wash applied late. On the important issue of injury to beneficial insects, Dicker (Ref. 9) believes that the danger is slight since there are few such insects on the trees at Bud Burst. This stage of development is usually reached at least one month before blossom time.

Raspberry Beetle (*Byturus tomentosus*). Wiesmann (Ref. 18), in a small-scale trial, sprayed raspberries once before blossoming and again at full flower with 1 per cent. Gesarol (0.05 per cent. D.D.T.). There was a marked reduction in the number of adult beetles to be found on the plants, and although only a small sample of the fruit was examined, the larval infestation also was obviously much reduced.

Shaw (Ref. 51) carried out a large-scale trial on loganberries, in this case aiming at control of the larval stage. Sprays containing 0.05 per cent. and 0.025 per cent. D.D.T. were compared with a Lonchocarpus spray equivalent to about 0.011 per cent. rotenone and with no treatment. When only one application was made, and that late, a heavy infestation was reduced by about 50 per cent. and there was no difference between either concentration of D.D.T. and Lonchocarpus. Where two applications were made at the orthodox times a moderate infestation of about 20 per cent. was reduced to about 2 per cent. and again there was no difference between treatments. Further trials (unpublished) have indicated that 0.0125 per cent. D.D.T. is only a little less effective than 0.025 per cent. and that the latter concentration is equally effective as dispersed solid or in an emulsion.

Despite these very favourable results, however, D.D.T. cannot be recommended for Raspberry Beetle control until a good deal more is known about its effect on the general orchard fauna when applied at this season (June).

Codling Moth (*Cydia pomonella*). Wiesmann's results (Ref. 18), using 1 per cent. Gesarol

(0.05 per cent. D.D.T.), against this insect were very variable, and much more consistent reports have come from the United States where, however, higher concentrations were used. In laboratory tests Siegler (Ref. 52) found that at 0.12 per cent. D.D.T. was more effective than 0.48 per cent. lead arsenate. Steiner, Arnold and Summerland (Ref. 20) carried out a field trial in Indiana against later generations of Codling Moth, lead arsenate having failed to control the earlier attack. They found either 0.09 per cent. or 0.18 per cent. D.D.T. to be superior to lead arsenate at 0.36 per cent. (3 lb. per 100 U.S. gall.), but there was a noticeable increase in the population of Red Spider on the trees treated with D.D.T. Ladybirds disappeared temporarily from these plots, but recolonization occurred later and the Red Spider attack was checked. Graham (Ref. 53) working in Maryland achieved similar success with 0.12 per cent. D.D.T. whether used throughout or after several lead arsenate sprays in six or seven post-blossom cover sprays. At 0.06 per cent the comparison was less favourable to D.D.T. Again there was a severe attack of Red Spider on the D.D.T. plots. Harman (Ref. 54) showed in New York State that 0.096 per cent. D.D.T. was as good as 0.36 per cent. lead arsenate in a full schedule of five sprays. A dust containing 3 per cent. D.D.T. was not nearly so effective. No increase in Red Spider was noticed, but this pest is not important in this area. In Kent 0.05 per cent. D.D.T. was rather less effective than 0.2 per cent. lead arsenate, each applied once in mid-June.

It seems probable that 0.1 per cent. D.D.T. could successfully replace the usual lead arsenate treatment for Codling Moth in this country, but as in the case of Raspberry Beetle no such recommendation is justified at present. Experience in Switzerland emphasizes the need for caution. Schneider (Ref. 26) states that after being officially recommended for several years against Codling Moth, Gesarol has now been withdrawn from the list following inconsistent results and the increase in Red Spider. He attributes occasional failures to insufficient resistance to rain of the deposit on the smooth surface of the fruit.

Tomato Moth (*Polia oleracea*). Chambers, Hey and Smitt (Ref. 55) claimed excellent results with an unspecified D.D.T. wash in commercial glasshouses, but it remained for Read (Ref. 56) to provide evidence of the excellent performance of this material. A 5 per cent. D.D.T. dust on kaolin, applied at 1 oz. per 20 plants, killed caterpillars of all sizes. The dusted foliage remained toxic to fully-grown larvae for twelve days and to one-day-old larvae for twenty days. When eggs were dusted, many larvae died in process of hatching. A spray containing 0.02 per cent. D.D.T. killed all stages and the sprayed foliage was still toxic to half-inch (4th instar) larvae after six days.

The need for a petroleum wash to control Red Spider under glass prompted the trial of a combined wash. In a small glasshouse and in large-scale trials under commercial conditions 0.0215 per cent. D.D.T. mixed with a 1 per cent. petroleum emulsion gave complete control, not only caterpillars but moths also being killed. An emulsion containing 0.01 per cent. D.D.T. and 0.75 per cent. petroleum oil was toxic to all but fully fed larvae. D.D.T. can be incorporated in the stock emulsion of the oil as an alternative to adding it to the diluted wash.

Although certain points of detail remain to be worked out, it is obvious that D.D.T., either as a 5 per cent. dust or as a 0.02 per cent. spray with or without petroleum oil, shows great promise for the control of Tomato Moth. Dusts are particularly attractive because of the ease and rapidity with which they can be applied. The problem of repeated reinfestation of the houses remains a serious practical difficulty.

Red Spiders (*Tetranychus telarius* and *Oligonychus ulmi*). These call for particular mention in that they are the outstanding examples of pests against which D.D.T. seems to be quite ineffective. Boyce (Ref. 57) commented on the failure of D.D.T. to control Red Spider on citrus, and Weigel (Ref. 43) found it ineffective as dust, spray, or aerosol against Greenhouse Red Spider. The increase in Fruit Tree Red Spider infestations following

D.D.T. sprays has already been mentioned and many observers in Britain have confirmed the ineffectiveness of D.D.T. against this pest. Predaceous insects play an important part in determining the course of summer attacks of Red Spider and as many of these predators, including ladybirds and certain capsids, are susceptible to the action of D.D.T. the possible consequences of widespread use of this substance are evident. The net result, however, cannot be predicted with any assurance and only large-scale trials over a period of years are likely to reveal it. After several years of commercial use against Codling Moth in Switzerland there has been a notable increase in Red Spider (Schneider, Ref. 26).

Among other fruit pests against which D.D.T. has been used successfully are **Winter Moth caterpillars** (*Operophtera brumata*), **Plum Sawfly** (*Hoplocampa flava*), **Plum Red Maggot** (*Cydia funebrana*), **Strawberry Blossom Weevil** (*Anthonomus rubi*) (Wiesmann, Ref. 18), **Gooseberry Sawfly** (*Nematus ribesii*), **Raspberry Cane Midge** (*Thomasiniana theobaldi*), and various **capsids.** It has shown little promise against **Apple Sawfly** (*Hoplocampa testudinea*).

There is evidence that several species of **Thrips** and also **Mushroom Flies** can be controlled by D.D.T.

Lice and Fleas. The control of lice and fleas on humans was one of the earliest as well as one of the most spectacular successes of D.D.T. Already millions of subjects have been treated and incipient outbreaks of louse- and flea-borne diseases have been checked. Similar success has attended the use of D.D.T. either as dust or as spray on farm and domestic animals, notably against lice on pigs and goats, and fleas on dogs and cats.

Sheep Blowfly (*Lucilia sericata*) and **Sheep Ticks** (*Ixodes ricinus*). In a series of laboratory tests Burtt found that each of these pests was very easily killed by D.D.T. and as a result large-scale field trials were started.

Cragg (Refs. 9, 12), working mainly in North Wales on Welsh Mountain sheep, found that dipping in a bath containing 0.5 per cent. D.D.T. as a finely dispersed emulsion gave effective protection for six weeks against **Blowfly.** This performance was far better than that of a commercial arsenic-sulphur spray used for comparison. Although results were not so uniformly good in some other areas, it seems certain that D.D.T. will give longer protection and a reduced number of strikes as compared with any material at present in use. Since the strikes that do occur are mainly around the tail, it is probable that enhanced control would result from a combination of the insecticide treatment with crutching. The attack on the adult fly does not demand penetration of the insecticide to the base of the fleece, so spraying of the animals may replace dipping.

Heath and Mitchell (Ref 9) have described trials on the control of **Ticks** on hill sheep in Cumberland. Dipping in a coarse emulsion containing 0.5 per cent. D.D.T. gave good control of ticks for seven weeks, against the two weeks following a commercial arsenic dip ; 0.3 per cent. D.D.T. gave protection for four weeks When, however, a more finely dispersed and therefore more stable emulsion was used, the results were very much interior, because of the smaller amount of D.D.T. deposited in the fleece. On the other hand, using an emulsifier of different type, 0.2 per cent. D.D.T. was effective because of the greatly increased affinity of the emulsion for the wool fibre. Pre-treatment of the fleece with acetic acid greatly increased its affinity for the normal type of emulsion.

In the course of these trials it was observed that **Keds** were completely eliminated by the D.D.T. dips. Matthysse (Ref. 58), however, has reported that in New York State *Melophagus ovinus* was almost unaffected by a 5 per cent. D.D.T. dust applied by a power blower.

Stable Flies, etc. Wiesmann (Ref. 59) reported completely successful control of flies in cowsheds by spraying the walls with 1 per cent. Gesarol (0.05 per cent. D.D.T.) and claimed that two sprayings, early in June and early in August, would keep stables or shippons free from flies throughout the summer. Recent collaborative experiments at a number of cen-

tres in Great Britain (Refs. 9, 60) have not altogether confirmed these results. Although the kill of flies was undoubtedly very high several factors militated against complete control. Some of the flies, notably *Lyperosia irritans*, do not leave the animals even when gorged, and so do not come into contact with sprayed surfaces. Rapid re-infestation occurs through open doors and windows and by flies (especially *Stomoxys calcitrans* and *L. irritans*) carried on the incoming cattle. Spraying the cattle did not greatly improve matters, probably because of the slowness of action of the insecticide and the repeated renewal of the fly population. Steer (Ref. 9) observed, however, that despite these facts the cattle in sprayed shippons were usually quieter than those in unsprayed. Blaxter (Ref. 60) concludes that while D.D.T. alone is not likely to solve the problem of stable flies, it will be a useful adjunct to screening and measures of general farm hygiene. The persistence of D.D.T. makes it practicable to treat fence posts, trees, etc. around farm buildings and so, possibly, to effect an appreciable reduction in the reservoir of fly population. Simmons and Wright (Ref. 61) have greatly reduced the fly infestation on manure heaps by applying emulsions containing 0.1 per cent. D.D.T. and this, too, may prove a useful contributory measure to the control of flies in farm buildings.

The discovery by Campbell and West (Ref. 6) that the activity of D.D.T. was manifest even when the substance was incorporated in distempers or oil-bound water paints opens up many possibilities of fly control. Walls treated with such preparations remained toxic to flies for at least two months.

Out of the foregoing possible applications of D.D.T. to the control of agricultural pests, tentative recommendations could probably soon be made for use against Flea Beetles, Cabbage Caterpillars, Apple Blossom Weevil, Sheep Blowfly, Sheep Ticks and, perhaps Carrot Fly, Tomato Moth, and Stable Flies. Very much more information in several directions is needed in the case of even the most promising of the others. Miscellaneous pests against which D.D.T. has been found very effective include ants, earwigs, and wasps.

Benzene Hexachloride.

By perhaps the most striking of all the coincidences associated with these new insecticides, the biological activity of benzene hexachloride seems to have been discovered independently and almost simultaneously in England and France at a time when there was no communication between the two countries. At the moment priority seems to rest with the French workers, for Raucourt (Ref. 62) states that in 1941 Dupire observed its toxicity to clothes moths and as a result submitted the material for tests against agricultural pests. According to Slade (Ref. 63), the I.C.I. discovery was made early in 1942 by Thomas, who was carrying out tests against **Turnip Flea Beetle.** The earliest reference in the literature concerns the French product, whose introduction and applications were discussed by Dupire and Raucourt (Ref. 64) in November, 1943. The I.C.I. product was mentioned as a secret preparation in the spring of 1944 (Ref. 65), but not until nearly a year later was its nature disclosed (Ref. 63).

Benzene hexachloride, $C_6H_6Cl_6$, has been known for over 120 years, having been prepared by Michael Faraday in 1824 by allowing benzene and chlorine to react together in sunlight. It is known alternatively as hexachloro*cyclo*hexane or, from its formula, "666." Because of the possibility of different arrangements in space of the hydrogen and chlorine atoms in the molecule, several stereo-isomeric forms exist. The precise number theoretically possible is a matter of some speculation, but four have been recognized and designated, *alpha*, *beta*, *gamma*, and *delta*.

The earlier results of biological tests in the I.C.I. laboratories were marked by puzzling inconsistencies which were not resolved until the separate isomers were isolated and tested. It was then found that the toxicity was located to a large extent in the *gamma* isomer and

variations in the amount present in the crude product accounted for the variable results. The newly-coined name "Gammexane" denotes this isomer, but unfortunately it has already been widely used, quite incorrectly, to refer to the mixed product benzene hexachloride or 666. The crude product of British manufacture contains about 10-12 per cent. of *gamma* isomer ; the French is believed to contain about half as much.

The French workers, although aware of the existence of isomeric forms, do not appear to have recognized the disparity in toxicity among them.

Unlike D.D.T., one preparation of benzene hexachloride has been used extensively on a commercial scale for three seasons. This is a dust containing 2 per cent. of the crude product (about 0.2 per cent. Gammexane). Slade mentions also emulsified forms and dispersible powders. For the preparation of certain emulsions, refined and partially concentrated products containing up to 50 per cent. Gammexane may be used. Since benzene hexachloride is moderately volatile and stable to fairly high temperatures, it can be vaporized by careful heating and so utilized as a 'smoke.'

Benzene hexachloride acts as a contact poison or stomach poison and is also sufficiently volatile to have pronounced fumigant properties. This measure of volatility, however, has some disadvantages for the substance has a penetrating and persistent smell which some individuals find very objectionable. While it is slow in action by comparison with pyrethrum, benzene hexachloride seems generally to be rather quicker than D.D.T. Thus Dicker (Ref. 9) reports that a 5 per cent. dust reached its maximum effect against Apple Blossom Weevil in sixteen hours, whereas a 5 per cent. D.D.T. dust required four to five days. On the other hand, the final kill was higher with D.D.T. The behaviour of houseflies poisoned by benzene hexachloride closely resembles that following contact with D.D.T., with the succession of phases somewhat accelerated.

Martin and Wain (Ref. 8) claim that benzene hexachloride fits in with and supports the hypothesis of insecticidal action due to liberation of hydrogen chloride. Slade (Ref. 63), however, speculates upon a more complex mechanism whereby some vital process in certain body cells is blocked by combination with a molecule closely resembling one that normally enters into the cell processes. This idea is based on the very close structural and physical resemblance between Gammexane and inositol, a substance essential to cell metabolism.

Benzene hexachloride is stated to be toxic to bees and fishes, but to have a very low toxicity to warm-blooded animals. Documented evidence, however, is lacking.

A few cases have been reported of apparent damage to *Brassica* seedlings, but there is a preponderance of evidence that the phytotoxic properties are slight.

In comparison with D.D.T., very little indeed has been published about laboratory or field trials with benzene hexachloride. Just as in the case of D.D.T., its first use in the field was, according to Dupire and Raucourt (Ref. 64), against the **Colorado Potato Beetle** where a 4 per cent. dust was highly successful. These authors also claim successes on a smaller scale against **Apple Blossom Weevil, Codling Moth, Flax Flea Beetles,** and **beetles** and **flies** infesting mushroom beds. Raucourt (Ref. 62) states that a 0.12 per cent. spray controlled **sawflies** and **Rhynchites** on fruit.

The British product was introduced as a substitute for derris dust against **Flea Beetles** and has given very satisfactory results. Miles (Ref. 34) has reported on one series of trials (see page 210), in which treatment with the commercial dust (2 per cent. benzene hexachloride) gave 63 per cent. of undamaged seedlings against 24 per cent. in the untreated controls. Dicker (Ref. 9) reports a single trial in which a 3 per cent. dust gave 50 per cent. control of **Apple Blossom Weevil.** Among other plant pests that have been successfully controlled on an experimental scale are **Pollen Beetles, Pea** and **Bean Weevils, Winter Moth caterpillars,** and **Cabbage caterpillars.** Martin and Wain (Ref. 8), however, found that the later instars

of the **Cabbage Moth caterpillar** were resistant. Results against aphides have been variable, but **Cabbage Aphis** (*Brevicoryne brassicae*), **Bean Aphis** (*A. rumicis*), and **Woolly Aphis** (*Eriosoma lanigerum*) are susceptible. A most interesting claim is that of success in controlling **Wireworms**; the outcome of further work against this pest is awaited.

Fruit Tree Red Spider does not appear to be appreciably affected by benzene hexachloride. No data are yet available about the effect on beneficial predaceous and parasitic insects, but it must be assumed for the present that all the precautions urged in the use of D.D.T. are no less necessary with benzene hexachloride.

In the field of animal parasites, Taylor (Ref. 66) found that a 1 per cent. solution of benzene hexachloride in liquid paraffin was a powerful acaricide (mite-killer) while being harmless to the experimental animals. He suggests that this preparation may prove to be of great value against **scabies,** including **sheep scab.**

Conclusion.

Much work still remains to be done with both D.D.T. and benzene hexachloride, especially in the direction of devising the most suitable formulations for particular purposes, of determining minimum concentrations for effective control, and of observing their cumulative effect upon the general fauna of treated areas.

The two materials have opened up entirely new possibilities in insect control, but with their bright promise they have brought also potential dangers. To meet this situation it is essential that the first few years of the commercial use of these insecticides should be regarded as an extension of the experimental phase. This period of extended trial should be entered upon with open minds free from prejudices in either direction, and with a willingness to accept and act upon the findings of careful and reliable observations. There is little doubt that if such a rational outlook is maintained towards the development of these materials, they are capable of facilitating perhaps the greatest single step forward that man has ever made in his unending contest against the insect world.

The writer desires to express his indebtedness to Mr. C. T. Gimingham for helpful comments on this review. He is very grateful also to several workers who have kindly allowed him to quote from reports in the press or not yet published.

H. SHAW.

East Malling Research Station,
Kent.

References

1. Läuger, P., Martin, H., and Müller, P. Über Konstitution und toxische Wirkung von natürlichen und neuen synthetischen insektentotenden Stoffen. *Helv. Chim. Acta*, 1944, **27**, 892.

2. Campbell, G. A. and West, T. F. Notes on D.D.T. *Chem. and Ind.*, 1944, No. 36 (September 2), 319.

3. Heilbron, I. M. The New Insecticidal Material D.D.T. *J. Roy. Soc. Arts*, 1945, **93**, 65.

4. J. R. Geigy. A.-G., 1942, British Patent Specifications 547,871 and 547,874.

5. West, T. F. and Campbell, G. A. D.D.T. *Industr. Chem.* 1944, **20**, 461.

6. Campbell, G. A. and West, T. F. D.D.T., The New Insecticide. *J. Oil and Colour Chem. Assoc.*, 1944, **27**, 241.

7. Martin, H., Stringer, A. and Wain, R. L. The Qualitative Examination of Insecticidal Properties. Progress Report-1943. *Long Ashton Res. Sta. Ann. Rept. for 1943* (1944), 62.

8. Martin H and Wain, R. L. The Qualitative Examination of Insecticidal Properties. Progress Report-1944. *Long Ashton Res. Sta. Ann. Rept. for 1944* (1945), 121.

9. Association of Applied Biologists. Symposium on Agricultural Uses of D.D.T. Report in *Nature*, 1946, **157** (in the press).

10. Fleck, E. E. and Haller, H. L. Compatibility of D.D.T. with Insecticides, Fungicides, and Fertilizers. *Ind. Eng. Chem.*, 1945, **37**, 403.

11. Wright, D. W. and Ashby, D. G. The Control of the Carrot Fly (*Psila rosae*, Fab.) (Diptera) with D.D.T. *Bull. Ent. Res.*, 1945, **36**, 253.

12. Cragg, J. B. 'D.D.T.' as a Sheep Blowfly Dip. *Nature*, 1945, **155**, 394.

13. Schneider, F. Können sich mit Gesarol vergiftete Insekten wieder erholen? *Schweitz. Zeit. Obst- u. Weinbau*, 1944, **53**, 401.

14. Bushland, R. C., McAlister, L. C., Jones, H. A. and Culpepper, G. H. D.D.T. Powder for the Control of Lice attacking Man. *J. Econ. Ent.*, 1945, **38**, 210.

15. Martin, H. and Wain, R. L. Insecticidal Action of D.D.T. *Nature*, 1944, **154**, 512.

16. Busvine, J. R. Insecticidal Action of D.D.T. *Nature*, 1945, **156**, 169.

17. Campbell, G. A. and West, T. F. Mode of Action of D.D.T. *Chem. and Ind.*, 1945, No. 42 (October 27), 335.

18. Wiesmann, R. Weitere Versuche mit Gesarol im Obstbau. *Schweitz. Zeit. Obst- u. Weinbau*, 1943, **52**, 171.

19. U. S. Dept. Agric. Report D.D.T. Test Results. *Soap*, 1945, **21**, No. 4, 193.

20. Steiner, L. F., Arnold, C. H. and Summerland, S. A. Laboratory and Field Tests of D.D.T. for Control of the Codling Moth. *J. Econ. Ent.*, 1944, **37**, 156.

21. Wiesmann, R. Neue Versuche mit Arsenersatzstoffen im Obstbau. *Schweitz. Zeit. Obst- u. Weinbau*, 1942, **51**, 154.

22. Wiesmann, R. Weitere Versuche über Gesarol und Honigbienen. *Schweitz. Zeit. Obst- u. Weinbau*, 1942, **51**, 245.

23. Holst, C. E. D.D.T. as a Stomach and Contact Poison for Honeybees. *J. Econ. Ent.*, 1944, **37**, 159.

24. Filmer, R. S. and Smith, C. L. D.D.T. as a Contact Poison for Honeybees. *J. Econ. Ent.*, 1944, **37**, 537.

25. Eckert, J. E. The Effect of D.D.T. on Honeybees. *J. Econ. Ent.*, 1945, **38**, 369.

26. Schneider, F. Der heutige Stand der Schädlingsbekämpfung im Obstbau. *Schweitz. Zeit. Obst- u. Weinbau*, 1945, **54**, 143, 151.

27. "F.K." Gesarol und Bienenzucht. *Schweitz. Zeit. Obs- u. Weinbau*, 1945, **54**, 91.

28. Gunther, F. A. Aspects of the Chemistry of D.D.T. *J. Chem. Educ.*, 1945, **22**, 238.

29. E. I. Du Pont de Nemours & Co., Inc. *U.S. Dept. Agric. Mimeograph*, 1945, E-644d.

30. Cameron, G. R. and Burgess, F. The Toxicity of D.D.T. *Brit. Med. J.*, 1945, No. 4407 (June 23), 865.

31. Wigglesworth, V. B. A Case of D.D.T. Poisoning in Man. *Brit. Med. J.*, 1945, No. 4397 (April 14), 517.

32. U.S. Federal Security Agency—Food and Drug Administration. Statement on D.D.T. September 5, 1945.

33. Kotte, W. Gesarol ein grosser Fortschritt in der giftfreien Schädlingsbekämpfung. *Sudwestdtsch. Zeit. Obst- u. Gartenbau*, July 1943, 52.

34. Miles, H. W. Experiments on the Control of Flea Beetles on Brassicae in the Western Province. *Long Ashton Res. Sta. Ann. Rept. for 1944* (1945), 145.

35. Johansson, E. Något om Olika Pudermedel mot Jordlopper. *Vaxtskyddsnotiser*, 1943, **7**, No. 6, 14.

36. Smith, C. E. and Harrison, P. K. Field Tests with D.D.T. and Other Insecticides Against Cabbage Caterpillars. *J. Econ. Ent.*, 1944, **37**, 152.

37. Apple, J. W. D.D.T. to Control Cabbage Caterpillars. *J. Econ. Ent.*, 1945, **38**, 410.

38. Bruce, W. N. and Tauber, O. E. Trials with D.D.T. on Potatoes, Cabbage and Squash. *J. Econ. Ent.*, 1945, **38**, 439.

39. Geigy Literature (1944). The Use of Guesapon and Guesarol Against Soil and Root Insects.

40. Morrison, H. E., Mote, D. C. and Rasmussen, W. B. D.D.T. to Control the Carrot Rust Fly. *J. Econ. Ent.*, 1945, **38**, 283.

41. Granovsky, A. A. Tests of D.D.T. for the Control of Potato Insects. *J. Econ. Ent.*, 1944, **37**, 493.

42. Gyrisko, G. G., Jodka, J. F. T. and Rawlins, W. A. D.D.T. to Control Potato Insects. *J. Econ. Ent.*, 1945, **38**, 169.

43. Weigel, C. A. D.D.T. Against Some Pests of Vegetable Crops. *J. Econ. Ent.*, 1944, **37**, 150.

44. Smith, F. F., and Goodhue, L. D. D.D.T. Aerosols to Control Onion Thrips and Other Pests in Greenhouses. *J. Econ. Ent.*, 1945, **38**, 173.

45. Goodhue, L. D., Smith, F. F. and Ditman, L. P. D.D.T. in Aerosol Form to Control Insects on Vegetables. *J. Econ. Ent.*, 1945, **38**, 179.

46. DITMAN, L. P., SMITH, F. F., GOODHUE, L. D. and BRONSON, T. E. D.D.T. Aerosols for Pea Aphid Control. *J. Econ. Ent.*, 1945, **38**, 183.

47. SMITH, F. F., DITMAN, L. P. and GOODHUE, L. D. Experiments with Aerosols Against Some Pests of Truck Crops. *J. Econ. Ent.*, 1945, **38**, 189.

48. CHAMBERS, V. H. and HEY, G. L. An Experiment with D.D.T. for the Control of Apple Blossom Weevil. *Fruit*, 1944, **5**, 218.

49. COLE, L. W. L. and HEELEY, W. This Year's Trials with D.D.T.: First Results. *Grower*, 1945, **23**, 430.

50. EDMONTON, W. E. and VINING, H. W. Field Trials with D.D.T. against Apple Blossom Weevil. *Fruit-grower*, 1945, **100**, 44.

51. SHAW, H. Field Trials of Dichloro-diphenyl-trichloroethane (D.D.T.) against the Raspberry Beetle (*Byturus tomentosus* Fabr.). *J. Pomol.*, 1945, **21**, 140.

52. SIEGLER, E. H. Laboratory Tests of D.D.T. Against the Codling Moth. *J. Econ. Ent.*, 1944, **37**,157.

53. GRAHAM, C. D.D.T. Sprays to Control Codling Moth in Maryland. *J. Econ. Ent.*, 1945, **38**, 272.

54. HARMAN, S. W. D.D.T. in the Codling Moth Program for Western New York. *J. Econ. Ent.*, 1945, **38**, 280.

55. CHAMBERS, V. H., HEY, G. L. and SMITT, N. K. D.D.T.—A Review. *Fruit-grower*, 1944, **98**, 178 and 218.

56. READ, W. H. A Preliminary Report on the Control of Tomato Moth Caterpillars with Preparations Containing D.D.T. *Rept. Exp. Res. Sta. Cheshunt for 1944* (in the press).

57. BOYCE, A. M. Up to Now with Citrus Insecticides. *Calif. Citrograph*, 1944, **29**, 117.

58. MATTHYSSE, J. G. Large Scale Power Dusting of Feeder Lambs for Winter Control of the Sheep Tick. *J. Econ. Ent.*, 1945, **38**, 285.

59. WIESMANN, R. Eine neue Andwendungsmöglichkeit des Arsenersatzstoffes "Gesarol." Bekämpfung der Fliegenplage in Stallen. *Schweitz. cit. Obst- u. Weinbau*, 1942, **51**, 329.

*60. BLAXTER, K. L. Control of Flies in Cowsheds. *Agriculture*, 1945, **52**, 112.

*61. SIMMONS, S. W. and WRIGHT, M. The Use of D.D.T. in the Treatment of Manure for Fly Control. *J. Econ. Ent.*, 1944, **37**, 135.

62. RAUCOURT, M. Découverte Recente d'un Nouvel Insecticide l'Hexachloro*cyclo*hexane. *La Nature* 1945, No. 3093 (August 1).

63. SLADE, R. The Gamma Isomer of Hexachloro*cyclo*hexane (Gammexane). *Chem. and Ind.*, 1945, No. 40 (October 13), 314.

64. DUPIRE, A. and RAUCOURT, M. Un Insecticide Nouveau: L'Hexachlorure de Benzène. *Comptes Rend. Acad. Agric., France*, 1943, **29**, 470.

65. ANON. U.N.R.R.A. See Research. *Farmer & Stockbreeder*, 1944, No. 2847 (May 2), 688.

66. TAYLOR, E. L. Acaricidal Property of a New Insecticide, Hexachlorobenzene. (*sic* !). *Nature*, 1945, **155**, 393.

REPORT FOR 1945 OF THE EXECUTIVE COMMITTEE TO THE COUNCIL, GOVERNORS AND MEMBERS OF THE SOCIETY

Now that hostilities have ceased, the work of the Executive Committee appointed in November, 1939 comes to an end. The Council and Standing Committees have resumed their normal functions, and next December it should be possible again to hold an Annual General Meeting of Governors and Members. Following the procedure adopted last year, this final Report of the Executive Committee, with the audited Accounts and Balance-sheet for the year, is being included in the pages of the Journal.

End of the War in Europe.

Immediately upon the announcement of the end of the war in Europe the President wrote to His Majesty The King, Patron of the Society, expressing the loyal and humble duty of the Governors and Members and their congratulations on the victorious termination of this campaign. His Majesty was graciously pleased to send a personal telegram from Buckingham Palace to the President conveying His Majesty's sincere thanks for his letter.

Membership.

Since the Committee presented their last Annual Report, the list of Governors and Members has undergone the following changes :—39 Governors (including 8 transferred from the list of Members under Bye-law 9) and 555 new Members have joined the Society, whilst the deaths of 6 Life Governors, 3 Governors, 61 Life Members and 122 Members have been reported. Four Life Members and 3 Members have been struck off the books under Bye-law 12 owing to absence of addresses, 34 Members under Bye-law 13 for arrears of subscription, and 5 Governors and 40 Annual Members have resigned.

During the year the Society has lost by death one Trustee (Lord Desborough), one Vice-President (Sir Walter Gilbey) and one ordinary member of Council (Mr. Albert Weightman) . and, within the first few days of 1946, Mr. Wm. Smith, Member of Council for Hereford, died very suddenly. Mr. Smith was a great authority on Hereford Cattle and a man of charming disposition who gave much of his time to public work.

Lord Desborough had been associated with the Society since 1888 and occupied the Presidential chair in 1926, when the Show took place at Reading.

Sir Walter Gilbey, like his father before him, rendered long and useful service to the Society, of which he became a member in 1881. He had served on the Council since 1916, when he was elected for the division of Essex.

Mr. Weightman became a member in 1916, and twenty years later was elected to the Council as the representative of the County of Durham, where as a progressive dairy farmer he achieved a high reputation. He was well known, too, as a breeder and successful exhibitor of British Friesian cattle, and his services as a judge of the breed were in great demand.

Amongst other Governors and Members whose loss by death the Society has to deplore are the Marquess of Crewe, K.G., Earl Lloyd George, O.M., the Earl of Mexborough, the Earl of Scarborough, K.G., Viscount Elveden, Lord Lilford, Sir Laurence E. Halsey, K.B.E., Sir R. F. Lancaster, Lady Margaret Boscawen, Mr. W. F. Holt Beever, Colonel F. J. Carruthers, C.B., Mr. Harry German, C.B.E., Mr. A. E. Gerrard, Mr. T. A. Edney Hayter,

Captain Douglas Lithgow, Mr. E. G. H. Maddy, Mr. James Muir, Mr. Herbert Padwick, C.B.E., Mr. R. G. Patterson, O.B.E., Mr. Lewis Priestman, Mr. Leslie R. Pym and Mr. Alec Todd.

Numbers on Register.

These and other changes bring the total number of Governors and Members on the Register to 7,321, divided as follows :—

140 Life Governors ;
166 Annual Governors ;
1,415 Life Members ;
5,579 Annual Members ;
21 Honorary Members ;

7,321 Total number of Governors and Members, as against a total of 7,012 at the time of the last report.

President for 1946.

Viscount Bledisloe, P.C., G.C.M.G., K.B.E., has been elected by the Council as President of the Society for 1946.

Council.

Vacancies in the list have been filled by the election of Lord Hastings as a Trustee, Lord Cranworth and Sir Lindsay Everard as Vice-Presidents, and the following ordinary members of Council :—The Duke of Grafton (Suffolk), Major M. E. Barclay (Hertfordshire), Major Philip Pease (Durham), and Major the Hon. Arthur Hazlerigg (Leicestershire)

Congratulations.

During the year the Council have had the pleasure of congratulating Lord Hazlerigg and Lord Courthope on their elevation to the Peerage.

Secretary.

Mr. Alec Hobson, O.B.E., at present Secretary of the National Pig Breeders' Association and the Small Pig Keepers' Council, has been appointed Secretary of the Society to succeed Mr. T. B. Turner, M.V.O., who will relinquish the appointment on the 30th March next.

Editor of Journal.

Dr. Charles Crowther, who recently retired as Principal of Harper Adams Agricultural College, Newport, Salop, has been appointed to succeed Mr. J. A. Scott Watson as Editor of the *Journal* and will commence his duties with the preparation of Volume 107 of this publication for the year 1946.

Post-War Policy.

Governors and Members will have observed with interest the very great similarity in the Policy for Agriculture announced by the Government and that put forward in the Society's Memorandum and the Statement issued by the Society in May 1944 after a conference attended by representatives of all agricultural bodies [This Statement will be found on page 70 of the *Journal* for 1944, Vol. 105].

Chemist's Report.

During the past year Members have submitted 60 samples for analysis, approximately the same number as in the previous year.

The samples consisted of waters, soils, feeding stuffs, fertilizers and certain miscellaneous items such as dead puppies and chickens suspected of being poisoned. In the case of the twelve samples of water one only was satisfactory from a bacteriological aspect. Sewage pollution was found in all the other samples, two being so bad as to constitute a positive danger to health if consumed in the raw state.

A material new to the country and known as Silico Phosphate was examined. This has a complex composition and is somewhat akin to the phosphate in the best kinds of basic slag. It contained approximately 33 per cent. of phosphoric acid (P_2O_5) and 1 cwt. of this Silico Phosphate is therefore equivalent to 2 cwt. of the ordinary pre-war grade of superphosphate. Silico Phosphate would be suitable for root crops and reseeding on phosphate deficient soils, and, as it is nearly three times as strong as the average grade of basic slag, only light dressing would be needed. The samples of Silage examined were good and had obviously been well made. It is surprising that greater use of silage is not made. It is easy to prepare, can be used over a very long period, can be used immediately it is ensiled and can be used for practically all classes of stock, with the possible exception of pigs. Silage is, in fact, a most convenient crop, and the old idea that it possesses an appreciably poorer nutritative value than the green crop from which it is made is, provided it is not sour, not a fact.

Many interesting letters dealing with various troubles have been received from Members. One of these dealt with two cows that exhibited a special liking for elder leaves. Apparently these two cows showed no alarming symptoms, which is curious as these leaves contained, besides a purgative alkaloid, a cyanogenetic glucoside similar to the one in almonds, and capable of developing an appreciable amount of prussic acid on digestion. The other cows in the herd would not touch these leaves.

A Member lost several young Guernsey calves through lead poisoning owing to the young calves licking the inside of painted doors. A synthetic resin paint, although difficult at the moment to obtain, would be ideal and quite harmless to cattle. In the absence of such a paint practically any type that was free from lead, copper, arsenic and soluble barium would be satisfactory.

Sir Rowland Biffen's Resignation.

It is with feelings of sincere regret that the Committee have to report the resignation of Sir Rowland Biffen, F.R.S., who succeeded William Carruthers as Consulting Botanist to the Society some 35 years ago. From 1908 to 1931 he was Professor of Agricultural Botany at Cambridge. Throughout his teaching career he was famous for his clear, impressive and inspiring instruction which, at one time and another, covered every branch of agricultural botany. In the organization and early life of the National Institute of Agricultural Botany he played a leading part. Farmers probably will know Sir Rowland best for his wheats; he was a pioneer of the application of genetical science to practical breeding. Some years ago Fream's *Elements of Agriculture* was revised by Cambridge authors under Sir Rowland as editor.

Animal Diseases.

While the numbers of outbreaks during 1945 of the scheduled diseases, given in the official returns of the Ministry of Agriculture, all show some decrease when compared with the preceding year, the position cannot be regarded as satisfactory, especially in the case of foot and mouth disease. The prevalence of this disease was the subject of a discussion in the Council last May when a resolution was passed :—

> "That this Council greatly deplores the excessive prevalence of foot and mouth disease through carelessness in the disposal of butchers' offal from imported carcasses, and the access of pigs and other livestock to such offal; strongly deprecates the lenient treatment by local benches of magistrates of many of those proved to be responsible for thus spreading the disease, and respectfully urges the Home Office and the local authorities to take drastic steps to check the serious loss of milk, meat and public money which these occurrences involve."

Importation of Pedigree Animals.

The Society has been notified by the Ministry of Agriculture during the year of the importation, under various Acts of Parliament, of pedigree animals of the Holstein and Ayrshire Breeds, from Canada; and of Polled Hereford cattle from the United States.

Medals for Cattle Pathology.

In the annual examination conducted at the Royal Veterinary College this year for the Society's medals for Cattle Pathology the silver medal was gained by P. L. Ingram, Kingswood, Main Avenue, Moor Park, Northwood, Middlesex, and the bronze medal by P. Kiddle, Bull Farm, King's Worthy, Winchester.

National Diploma in Agriculture.

As in the previous year, two examinations were held in 1945 for the National Diploma in Agriculture. For the first, at Edinburgh in April, 132 candidates appeared; at the second, at Leeds in July, 218 candidates presented themselves. Following are the names of those who gained the Diploma—34 at Edinburgh and 72 at Leeds:—

EDINBURGH EXAMINATION.

Diploma.

GEOFFREY EDWIN BARNSLEY, Harper Adams Agricultural College.
JOHN BARRETT, Royal College of Science, Dublin.
FRANCIS JAMES BENNISON, Harper Adams Agricultural College.
JOHN PERCIVAL BLENKINSOP, University of Leeds.
WALTER BOX, University of Glasgow and West of Scotland Agricultural College.
JOHN WEST BURRELL, University of Leeds.
WILLIAM COWIE, University of Glasgow and West of Scotland Agricultural College.
WINSOME DONALDSON, West of Scotland Agricultural College.
ALAN JAMES EDWARDS, Midland Agricultural College.
DAVID EXLEY, University of Leeds.
JAMES WOOSNAM GORE, University of Reading.
JEAN HEMSLEY, West of Scotland Agricultural College.
WILLIAM CHARLES JACKSON, Midland Agricultural College.
ELINOR WYN JONES, Harper Adams Agricultural College.
ALEXANDER KING, West of Scotland Agricultural College.
JOHN LOWE, West of Scotland Agricultural College.
MURDOCH MACDONALD MACCOWAN, University of Glasgow and West of Scotland Agricultural College.
IAN EDWARD MCLEAN, University of Glasgow and West of Scotland Agricultural College.
BERNARD MAHER, University of Leeds.
JOHN CHARLES MATTHEWS, University of Reading.
IAN WATSON MITCHELL, University of Glasgow and West of Scotland Agricultural College.
PHILIP ALFRED NAYLOR, University of Leeds.
ROBERT ERNEST PAGET, West of Scotland Agricultural College.
DENNIS CECIL PRICE, University of Leeds.
GEOFFREY RIGHTON, University of Reading.
ALAN MUIRHEAD SIMPSON, West of Scotland Agricultural College.
JAMES GORDON SMITH, West of Scotland Agricultural College.
EDGAR STICKLAND, Midland Agricultural College.
THOMAS UMPLEBY, University of Leeds.
ALFRED WALSH, University of Leeds.
JAMES CRAIG WARDROP, University of Glasgow and West of Scotland Agricultural College.
JAMES FARQUHARSON WHITSON, University of Glasgow and West of Scotland Agricultural College.
DENNIS FRANK WILSON, University of Leeds.
LEONARD JOHN PATRICK WOODRUFF, University of Reading.

LEEDS EXAMINATION.

Diploma with Honours.

TREVOR JONES, Harper Adams Agricultural College.

Diploma.

PETER JOHN ALLDEN, University of Reading.
DAVID SHARDLOW ALLEN, Midland Agricultural College.
PETER STRETTON ALLEN, Midland Agricultural College.
HUMPHREY GILMAN BACK, Midland Agricultural College.
DENVER GEORGE BAGLOW, Seale Hayne Agricultural College.
WALTER DAVIDSON BEARD, Midland Agricultural College.
PETER BEESE, Harper Adams Agricultural College.
ASHLEY MICHAEL BEHAGG, Harper Adams Agricultural College.
JOSEPH ALAN BLACK, Midland Agricultural College.
WILLIAM ERNEST GEORGE BOLT, Seale Hayne Agricultural College.

Anne Patricia Bowater, University of Reading.
Arthur Peter Fyson Buck, Midland Agricultural College.
John Percival Calthorpe, Midland Agricultural College.
Anthony Martin Chart, Harper Adams Agricultural College.
Eric Charles Harry Chase, University of Reading.
James Clark, University of Glasgow and West of Scotland Agricultural College.
George Douglas Clegg, Midland Agricultural College.
Donald William Cooper, University of Glasgow and West of Scotland Agricultural College.
William Colin Cowlishaw, Midland Agricultural College.
Robert Peter Davies, Midland Agricultural College.
Robert Sydney Davis, Seale Hayne Agricultural College.
Peggy Isis Dawson, Midland Agricultural College.
Roger Alan Dudman, Harper Adams Agricultural College
Derrick Evered Dunn, Harper Adams Agricultural College.
Ivor John Faulkner, Harper Adams Agricultural College.
Arthur John Fox, Harper Adams Agricultural College.
David Marsh Garratt, Harper Adams Agricultural College.
George Colin Rollinson Gibson, Midland Agricultural College
Ivo Michael Godfrey, Midland Agricultural College
John Derrick Benjamin Griffin, Seale Hayne Agricultural College.
Thomas Garstang Gudgeon, Harper Adams Agricultural College.
Ian Peter Guthrie, Harper Adams Agricultural College.
Peter Allen Haughton, Midland Agricultural College
Patrick Heron, Seale Hayne Agricultural College.
James Rex Hopwood, Seale Hayne Agricultural College.
Peter Michael Hurrell, University of Leeds
John Albert Jones, University of Reading.
William Kenneth Pryce Jones, Harper Adams Agricultural College
Margaret Gwendoline Knowles, Midland Agricultural College.
Tom Lievesley, Midland Agricultural College.
Josephine Berta Mary Longstaffe, Harper Adams Agricultural College
Leslie Marshall, University of Leeds
Daniel William David Langdon Mead, University of Reading
Owen Middleton, Midland Agricultural College.
David Richard Mumford, Midland Agricultural College
Gerald Ralph Pain, Harper Adams Agricultural College
Maisie Yvonne Price, Seale Hayne Agricultural College
Arnold Trevor Smith Ramsbottom, Midland Agricultural College
Bryan Peter Richardson, University of Leeds
Ralph Sampson, Midland Agricultural College
Gilbert Ernest William Sercombe, Seale Hayne Agricultural College
Robert Simpson, University of Reading.
Thomas Edmund Alwyne Simpson, Midland Agricultural College.
Edward Stevens, Harper Adams Agricultural College.
Arthur Lang Stewart, West of Scotland Agricultural College.
Cecil David Taylor, University of Reading.
Herbert Sidney Taylor, Harper Adams Agricultural College.
Philip Salizé Taylor, Midland Agricultural College
Ralph William Thompson, Midland Agricultural College
Philip John Turner, Midland Agricultural College.
Robert William Wakeley, Midland Agricultural College.
Bryan Stewart Wakely, Seale Hayne Agricultural College.
Gerald Ronald Watkins, Midland Agricultural College
Mrs, Dorothy Westoby, Midland Agricultural College.
Philip Charles Weston, Midland Agricultural College
Robert Alan Weston, Midland Agricultural College.
Raymond Frank Whitworth, University of Reading.
Hopkin John Williams, University of Reading.
Geoffrey Ralph Wilson, University of Reading.
Sydney Charles Wittering, Midland Agricultural College.
Charles Stuart Young, Midland Agricultural College.

N. D. A. and P. O. W.

The National Agricultural Examination Board has arranged to allow Prisoners of War who were attending lectures and courses in Agriculture in their Prisoner of War camps to sit for the examination this year. Those who had already passed in certain subjects will be allowed to complete the examination.

National Diploma in Dairying.

For the National Diploma in Dairying the 50th annual examination was held in September, at Reading for English and Welsh students, and at the Dairy School, Auchincruive, Ayr, for Scottish students. At the English centre 99 candidates were examined, of whom 54 were successful. In Scotland there were 60 candidates, of whom 23 passed. Names of Diploma winners are given below :—

English Centre.

JOYCE ALLISON, Midland Agricultural College.
DIANA MARY BATES, Studley College.
WENDY BEATRICE BELFIELD, Midland Agricultural College.
ROSEMARY BERRIDGE, Midland Agricultural College.
JULIETTE BIDE, The University and British Dairy Institute, Reading.
GEORGE WILLIAM BIRCHENOUGH, Midland Agricultural College.
VERONICA BONDI, Studley College.
ELIZABETH AUDREY BROAD, Seale Hayne Agricultural College.
GILLIAN MARY COOK, The University and British Dairy Institute, Reading.
ELONWY ANN DAVID, University College of Wales, Aberystwyth.
ELUNED POWYS DAVIES, University College of Wales, Aberystwyth.
JENNIE DAVIES, University College of Wales, Aberystwyth.
PAMELA EVELYN DOWLEN, Studley College.
VERA LAWRY EDDY, Midland Agricultural College.
MILLICENT ALICE EDWARDS, Seale Hayne Agricultural College.
BETTY MAY EVANS, Studley College.
MARGARET EILEEN FALKNER, Midland Agricultural College.
KATHLEEN MARY FISHER, Midland Agricultural College.
KENNETH LANCELOT GODDARD, Seale Hayne Agricultural College.
LETITIA MARY ALDWYTH GRIFFITHS, University College of Wales, Aberystwyth.
JUNE ANNETTE GROVER, Studley College.
MARY OLIVE GWYTHER, The University and British Dairy Institute, Reading.
JANETTE HADLEY, The University and British Dairy Institute, Reading.
MALCOLM HORACE HAGUE, Midland Agricultural College.
LESLIE STEPHEN HARRIS, University College of Wales, Aberystwyth.
MARGARET HELEN HEWETT, The University and British Dairy Institute, Reading.
BETTY HILL, Midland Agricultural College.
JOHN CHARLES HOCKEN, Seale Hayne Agricultural College.
KATHLEEN VALERIE JACQUES, The University and British Dairy Institute, Reading.
PATRICIA ISABEL JEWELL, The University and British Dairy Institute, Reading.
GWYNETH MAY JONES, University College of Wales, Aberystwyth
VIVIEN BONIWELL LAIDLAW, The University and British Dairy Institute, Reading.
JEAN LAMBERT, Midland Agricultural College.
HILDA R. LANG, The University and British Dairy Institute, Reading.
MARY PATIENCE LANG, The University and British Dairy Institute, Reading.
EMILY JEAN MCBRIDE, Midland Agricultural College.
HONOR ISABEL MALINS, The University and British Dairy Institute, Reading.
EMMA MARY MEGGINSON, Studley College.
PRISCILLA MARY MELLIS, The University and British Dairy Institute, Reading.
AVERIL DOROTHY NOWELL, The University and British Dairy Institute, Reading.
PENELOPE ELIZABETH PIPON, The University and British Dairy Institute, Reading.
JANE ELINOR PUGH, University College of Wales, Aberystwyth.
ANN COURTENAY CAREW ROBINSON, Studley College.
ELIZABETH MARY ROBSON, The University and British Dairy Institute, Reading.
JUNE SANDERS, University of Wales, Aberystwyth.
KATHLEEN JOYCE SKIDMORE, Studley College.
ELISABETH MARY STUDD, The University and British Dairy Institute, Reading.
PATRICIA TERRY, The University and British Dairy Institute, Reading.
GLYTHYN MARJORIE SARAH THOMPSON, University College of Wales, Aberystwyth.
JEAN MARGARET TILLEY, University College of Wales, Aberystwyth.
HELEN DAPHNE TONGE, University College of Wales, Aberystwyth.
JANET PATRICIA WEBBER, The University and British Dairy Institute, Reading.
DILYS RHYS WILLIAMS, University College of Wales, Aberystwyth.
EVANGELINE JOAN WILLIAMS, The University and British Dairy Institute, Reading.

Scottish Centre.

ELIZABETH STEWART PATERSON ADAM, Wolfelee, 54, Elvan Street, Motherwell, Lanarkshire.
RICHARD ROYDEN AVERY, 22, North View, Westerton, by Glasgow.

EILEEN CRAIGIE CARTER, Links, Papa Westray, Orkney Isles.
MALCOLM EDWARD CASTLE, 7, Roberttown Lane, Liversedge, Yorks.
ELIZABETH GREELEY CRUICKSHANK, Mill of Petty, Fyvie, Aberdeenshire.
CHRISTINE WEIR FERGUSON, Kilmhor, Carlibar Drive, Barrhead, Renfrewshire.
GRACE LOUISE SUTHERLAND FORBES, 178, Crieff Road, Hillyland, Perth.
EVELYN MARGARET BUCHANAN GOUDIE, 16, Belmont Gardens, Edinburgh 12.
JEAN HEMSLEY, Woodside, Red Row, Morpeth, Northumberland.
ANNE HENDERSON, Nowlands, Wester Essendy, Blairgowrie, Perthshire.
CLEATOR WILLIAM KELLY, "Almeda," 61, Bray Hill, Douglas, Isle of Man.
ELLEN DYKES MACFARLANE, "Westhouse," Strathaven, Lanarkshire.
CATHERINE ANN MCGREGOR, Strontoiller, by Oban.
MARION MACLEOD, Creaganan Gorma, Carloway, Stornoway, Isle of Lewis.
MARGARET JEAN DUNCAN MACPHERSON, 16, West Chapeltown Crescent, Bearsden, Glasgow.
FRANK RAYMOND NUTTALL, "Brooklyn," 132, Liverpool Road, Upton-by-Chester, Chester.
ELIZABETH ELEANOR PEACOCK, Beaconsfield House, Barnard Castle, Co. Durham.
MARY FYFE RUSSELL, 4, Eastwood Avenue, Giffnock, Glasgow.
MOIRA CHRISTISON SMART, 41, Milton Road West, Portobello, Midlothian.
RUBY DOROTHY SNOW, 12, Lyndhurst Drive, Sevenoaks, Kent.
ROBERT LEWIS SUTHERLAND, 31, Sheepburn Road, Uddington, Lanarkshire.
EILEEN ALEXANDRA URWIN, Temple House, Anglesey Road, Kingston-on-Thames, Surrey.
ANITA FERGUSON WHYTE, 3, Pelaw Terrace, Durham.

All but two of the candidates at the Scottish Centre had been students at the Dairy School for Scotland, Auchincruive, Ayr.

The National Dairy Examination Board have now under consideration the revision of the Syllabus with a view to bringing the Examination more into line with present day needs. A proposal has been made that the Examination should now be divided into two parts (*a*) Dairy Husbandry (*b*) Dairy Technology. A special Sub-Committee of the Board has been appointed to draft Regulations and a Syllabus for such an examination.

Long Service Certificates.

Certificates have been awarded to the following for long service on farms :—

GEORGE WALL	66 years on Manor Farm, Bishopstone, Swindon.
W. CARPENTER	64 years on Manor Farm, Awkley, nr. Bristol.
WILLIAM MORSE	63 years on Aller Farm, Williton, with G. L. Culverwell.
JOHN YAPP	60 years on Mill End Castle Frome, Ledbury, with two employers.
W. R. G. ROBBINS	57 tears on Manor Farm, St. Nicholas, Birchington
GEORGE HENRY LEGG,	49 years on Mappercombe Farm, Bridport, with two employers.
W. E. CARPENTER	45 years on Manor Farm, Awkley.
HERBERT NICHOLSON PEARSON	45 years on Honeypot Farm, Penrith, with three generations of the same family.
STEPHEN ABBOTT	45 years on Hewish Farm, Milborne St. Andrew, Brandford, with five employers.
J. R. FELTON	44 years, and still working on Great Bradley Hall Farm, near Newmarket.
WALTER POOLE	42 years as Stockman on the Earl of Strafford's Dancers Hill Farm, Barnet, Herts.
H. G. BUTLER	41 years on Impington Farm, Cambridge, with Chivers Bros., Ltd.
P. T. SMITH	41 years at Monkton Court, Minster, Thanet.
J. H. HERN	40 years on Manor Farm, Acton Tirrold, Berks., with F. J. K. Cross.
J. H. DENNIS	40 years on the Earl of Strafford's Home Farm, Wrotham Park, Barnet, Herts.

Service qualifying for an award is forty years on the same or different holdings with one employer, or forty years on the same holding with different employers. Farm workers (male or female)—excluding gardeners, grooms and gamekeepers—in any part of England or Wales are eligible for the awards. Claims on behalf of farm workers must be made through County Agricultural Societies on special forms which may be obtained from the Secretary of the Royal Agricultural Society of England, 16, Bedford Square, London, W.C.1.

"Queen Victoria Gifts."

There were again no unsuccessful applicants for pensions at this year's election of the Royal Agricultural Benevolent Institution, and, under the terms of the trust deed, the Trustees of the Queen Victoria Gifts Fund were precluded from making their annual grants. The amount available is therefore being retained for grants in future years.

Victory Churn Contest.

In the inter-county competition for the encouragement of increased milk production, the £100 Challenge Trophy offered by the Royal Agricultural Society was this year gained by the Soke of Peterborough. The formal presentation was made at the Farmers' Club in October by the Minister of Agriculture, from whom the President subsequently received a letter in the following terms :—

DEAR LORD COURTHOPE,

I was very glad you were able to attend the pleasant little function at the Farmers' Club on Wednesday last, when the Royal Agricultural Society's trophy was presented to the Soke of Peterborough people and you were able to hand them a diploma as a permanent memento of their achievements in milk production last winter.

You will recall that in my remarks I paid tribute to the Society's generosity in making this very handsome trophy available for national competition among the dairy farmers and their workers in the different counties, but I should not like the opportunity to pass without placing what I said on record. I should be glad, therefore, if you would convey to your Council my deep appreciation of their public-spirited action in making the Victory Churn Contest possible for the past three years and in providing such a valuable stimulus to the war-time milk production campaign.

Yours sincerely,
T. WILLIAMS.

The Rt. Hon Lord Courthope, M.C.

The competition will not be continued as it was a wartime feature : when the Soke of Peterborough has held the trophy for a year it will be returned to the Society and will be available for such purposes as they may wish to apply it.

Lincoln Show.

As Governors and Members will be aware, the Society will be unable for reasons explained in the *October Review* to hold their first post-war Show this year. It is hoped, however, that the long postponed visit to the City of Lincoln will take place in 1947.

New Show Regulations.

Meetings of the Veterinary and Stock Prizes Committees have been held to consider the question of restricting entries of cattle at future Royal Shows to animals that have successfully passed the prescribed tests for Tuberculosis and Contagious Abortion. The following resolutions were passed at a meeting on the 15th March last.

Proposed by Sir Archibald Weigall, seconded by Lt.-Col. Guy Blewitt :—

"That the time has now arrived when provision at the next Royal Show should be made for the exhibition of Cattle from Licensed, Attested or Supervised herds only, or those having passed a prescribed test for Tuberculosis 'X' weeks before the opening of the Show, and that entries be restricted to these groups."

A proposal that Cattle must have passed the Agglutination Test for Contagious Abortion within "X" weeks of the opening of the Show, or have been vaccinated with S.19 Vaccine, was defeated by 8 votes to 5.

Lord Digby then moved an amendment, and Mr. C. W. H. Glossop seconded :—

"That a Regulation should be introduced as soon as practicable, but not before 1947, to ensure that all animals at the Show have passed the approved Contagious Abortion Test or Tests."

This was agreed to

The resolutions have been accepted by the Council and further meetings to discuss the details are being arranged.

President's Visit to Argentina.

During the summer Lord Courthope paid a visit to the Palermo Show of the Sociedad Rural Argentina as the honoured guest of that Society. He was most lavishly entertained and his visit will have a very great effect in cementing the friendship between this country and the Argentine Republic and in removing misunderstandings. Lord Courthope presented a lengthy report to the Council at its meeting on the 24th October and fuller details are given in the Society's *Quarterly Review* for October last.

Judges at Palermo Show.

The following British Judges officiated at this year's show of the Argentine Rural Society :-- Lord Lovat, Shorthorn cattle : Mr Alexander Beddie, Aberdeen Angus cattle ; Mr. A. E. Moore, Hereford cattle.

Honorary Membership.

Last June, the Chairman of the Argentine Rural Society, Senor José Maria Bustillo, was elected an Honorary Member of the Royal Agricultural Society.

Lord Courthope, since his return to this country, has been honoured by the Argentine Rural Society and the Association of Shorthorn Breeders of Argentina, which have both conferred upon him their Honorary Membership.

Research.

The experiments on the residual manurial value of cake fed to grazing cattle at Rothamsted Experimental Station, the investigation into the cumulative effects on a light arable soil of various methods of disposal of sugar beet tops and straw at Norfolk Agricultural Station, Sprowston, and the grassland re-seeding trials at various centres are being carried through to completion, and it is hoped to give Governors and Members further details of these in the *Quarterly Review*.

Jamaica Agricultural Society.

On the occasion of its Jubilee in 1945 the President sent the following message of congratulation to the Agricultural Society of Jamaica :--

> President, Council, Governors and Members of the Royal Agricultural Society of England heartily congratulate Jamaica Agricultural Society on completion of 50 years active work for prosperity of Colonial Agriculture and appreciate close alliance and co-operation between our two bodies for scientific research and practical progress.
>
> We hope that members of your Society may visit our National Show before long and can assure you of a hearty welcome.
>
> COURTHOPE, *President.*

Farm, Dairy and Garden Apprenticeship Scheme.

The Executive Committee have accorded their approval and support for a scheme of apprenticeship in agriculture and horticulture outlined in a letter received from the Women's Farm and Garden Association.

Representation on other Bodies.

To represent the Society Sir Roland Burke has been appointed a member of the Council of the National Horse Association, and Mr. C. W. H. Glossop, M.P., a member of the Agricultural Electrification Advisory Committee of the British Electrical Development Association. Re-appointments include Sir Merrik Burrell on the Small Pig Keepers' Council and Mr. Turner on the Registration Committee of the Worshipful Company of Farriers.

Pictures.

The valuable pictures belonging to the Society which were removed to the country for safety have now been restored to their accustomed places on the walls of the Society's House.

Free Use of Rooms at 16, Bedford Square.

The Society's offer to allow Breed Societies and other Associations connected with Agriculture to use, free of charge, rooms at their Headquarters has been taken advantage of during the year by the following :—the Royal Veterinary College, the National Federation of Young Farmers' Clubs, the Women's Farm and Garden Association, the National Farmers' Union, the Rural Reconstruction Association, the Agricultural Education Association, the Sussex Cattle Society, the English Guernsey Cattle Society, the English Jersey Cattle Society, the English Ayrshire Cattle Breeders' Association, the National Horse Association, the National Pony Society, the Arab Horse Society, the Hackney Horse Society, the Hunters' Improvement Society, the British Show Hack & Cob Association, the Show Jumping Association, the National Sheep Breeders' Association, the Southdown Sheep Society, the National Pig Breeders' Association, the Small Pig Keepers' Council, the Large Black Pig Society, the Essex Pig Society, the Show Secretaries' Association.

These bodies, many of whom have been evacuated from their London Headquarters since 1939, have expressed themselves as most grateful for the accommodation afforded to them and their appreciation of the arrangements made for their meetings.

Red Cross Agriculture Fund.

A final donation of £500 has been made to the Red Cross Agriculture Fund during the past year, bringing the Society's total contribution to the Fund up to £2,500.

Other Donations.

The Society has also contributed £100 to the Educational Movement for Agriculture, 50 guineas to the Veterinary Educational Trust, and 10 guineas for British Electrical Research. The expenses of the annual general meeting of the National Federation of Young Farmers' Clubs will be defrayed by the Society.

Accounts and Investments.

As last year the Accounts for 1945 are presented to Governors and Members at the end of this report, as it is not possible to hold a General Meeting at which formal presentation would normally be made.

During the year the Society has invested from the Reserve Fund Account £2,700 in 3% Savings Bonds (1965-75); and the Special Show Reserve Fund has been augmented by a transfer from Ordinary Account of £2,500, which sum has been invested in 2½% National War Bonds (1954-56). Towards the end of the year the Society's holdings of £6,568 17s. 9d. 2½% National War Bonds (1945-47) and £5,000 2½% National War Bonds (1946-48) were sold for £6,569 15s. 1d. and £5,037 7s. 7d. respectively, the total sum realised (£11,607 2s. 8d.) being invested in 3% Savings Bonds (1965-75).

By order of the Executive Committee

T. B. TURNER,

Secretary.

16, Bedford Square,
London, W C.

February. 1946.

Royal Agricultural Society of England

16 BEDFORD SQUARE, LONDON, W.C. 1

STATEMENTS OF ACCOUNTS

AND

BALANCE SHEET

for Year ended

31st DECEMBER, 1945.

STATEMENT OF RECEIPTS AND

Figures for 1944 £	RECEIPTS.	£	s.	d.	£	s.	d.	£	s.	d.
	CASH AT BANKERS AND IN HAND, JANUARY 1, 1945 :—									
233	Reserve Fund Account				857	17	3			
2,338	Current Account				3,841	12	3			
75	Petty Cash at Bank and in Hand				92	1	0			
								4,791	10	6
2,646										
	SUBSCRIPTIONS :—									
943	Annual Governors	947	3	0						
5,498	Annual Members	5,722	7	9						
39	Life Governors and Members	49	7	0						
101	For previous years	33	11	0						
					6,752	8	9			
6,581										
	JOURNAL OF THE SOCIETY :—									
275	Advertisements	319	10	9						
94	Sales and Reprints	112	13	3						
					432	4	0			
369										
	EXAMINATIONS :—									
1,024	National Diploma in Agriculture	1,162	7	4						
342	National Diploma in Dairying	453	2	0						
					1,615	9	4			
1,366										
	MISCELLANEOUS :—									
7,134	Interest and Dividends on Investments . . .	7,239	18	4						
905	Income Tax refunded	842	10	1						
33	Bank Interest	42	13	1						
15	Sales of Pamphlets, etc.	17	9	10						
857	Sales of "Elements of Agriculture"	873	9	9						
2	*Hire of Rooms*	.	.	.						
104	Donations	103	10	0						
217	Park Royal Drainage Rate	123	6	4						
					9,242	17	5			
9,267										
17,583	TOTAL OF ORDINARY RECEIPTS							18,042	19	6
625	Life Compositions of Governors and Members ...				2,340	9	0			
65	Subscriptions for 1946				113	1	3			
								2,453	10	3
690										
	Overdraft at Bankers on Investment Account at 31st December, 1945 ... ... [(Overdraft pending receipt of proceeds of sale of £6,568 17s. 9d.—2½% National War Bonds (1945-47), and £5,000—2½% National War Bonds (1946-48).]				11,607	2	8			
	Less: Cash at Bankers and in hand at 31st December, 1945 :—									
	Reserve Fund Account	498	2	1						
	Current Account	4,126	3	3						
	Petty Cash at Bank and in Hand	169	18	5						
					4,794	3	9			
								6,812	18	11
£20,919								£32,100	19	2

Payments for the Year 1945.

Figures for 1944 £	PAYMENTS.	£	s.	d.	£	s.	d.	£	s.	d.
	General Administration :—									
3,670	Salaries, Wages and Allowances	3,828	0	0						
511	Pensions and Insurance Premiums	478	3	3						
163	Legal Charges, Auditor's Fees, etc.	142	17	0						
1,047	Rent, Rates and House Expenses	998	6	4						
337	Printing and Stationery	401	0	7						
278	Postage, Telephone and Sundries	298	1	2						
					6,146	8	4			
6,006										
	Journal of the Society :—									
765	Part cost of Volumes 105 and 106				1,499	15	11			
	Scientific Departments :— ...									
250	Chemist's Salary	250	0	0						
125	Botanist's Salary	125	0	0						
100	*Zoologist's Salary*	.	.	.						
400	Grant to Royal Veterinary College	400	0	0						
8	Medals *re* Cattle Pathology	6	1	2						
50	Grant to Research Institute, Reading	50	0	0						
					831	1	2			
933										
	Examinations :—									
1,075	National Diploma in Agriculture	1,192	7	7						
469	National Diploma in Dairying	534	7	4						
					1,726	14	11			
1,544										
	Miscellaneous :—									
660	Grant to Research Fund	630	0	0						
23	Repairs, etc., to House	8	12	9						
8	Certificates for Long Service	1	19	0						
1,206	"Elements of Agriculture": Reprints and Postage	1,090	13	4						
109	Park Royal Drainage Rate	228	13	10						
4,000	Amount set aside against expenses *re* Shows	4,000	0	0						
44	*Expenses re preparation of memorandum on post-war Agricultural Policy*	.	.	.						
13	*War Damage Insurance Premiums*	.	.	.						
18	Expenses *re* Air Raid Damage	2	11	11						
—	Donation to Malta Horticultural Society	10	0	0						
500	,, ,, Red Cross War Agriculture Committee .	500	0	0						
—	,, ,, Veterinary Educational Trust	52	10	0						
—	,, ,, N.F.U. Town and Country Education Propaganda	100	0	0						
—	,, ,, British Electrical and Allied Industries Research Association	10	10	0						
—	Contribution towards the President's expenses for his visit to the Argentine	300	0	0						
21	Victory Churn Contest—Diploma	21	0	0						
225	Publicity Adviser	300	0	0						
53	Quarterly Bulletin	333	5	4						
					7,589	16	2			
6,880										
16,128	**Total of Ordinary Payments**							**17,793**	**16**	**6**
—	Purchase of £14,307 2s. 8d.—3% Savings Bonds (1965-75)							**14,307**	**2**	**8**
	Cash at Bankers and in hand, December 31, 1944 :—									
858	*Reserve Fund Account*									
3,841	*Current Account*									
92	*Petty Cash at Bank and in Hand*									
4,791										
£20,919								**£32,100**	**19**	**2**

BALANCE SHEET,

Figures for 1944 £		£ s. d.	£ s. d.	£ s. d.
	CAPITAL AND RESERVE FUND :—			
266,267	As at December 31, 1944		267,798 9 7	
	SHOW FUND :—			
4,000	Contribution from Ordinary A/c.	4,000 0 0		
2,650	*Less* : Amount transferred to Special Show Reserve Fund	2,500 0 0		
1,350		1,500 0 0		
1,333	*Less* : Expenses not allocable to any Show	1,322 8 11		
			177 11 1	
17				
266,284			267,976 0 8	
	RECEIPTS AND PAYMENTS ACCOUNT :—			
	Ordinary Receipts...	18,042 19 6		
	Ordinary Payments	17,793 16 6		
			249 3 0	
1,455				
267,739			268,225 3 8	
187	*Less* : Adjustment *re* outstanding Assets and Liabilities		128 5 6	
267,552			268,096 18 2	
625	Life Compositions received in 1945		2,340 9 0	
73	Subscriptions in advance received in 1944		65 7 0	
268,250			270,502 14 2	
1,776	*Add* : Appreciation in market values of Investments		989 3 3	
270,026			271,491 17 5	
	DEPRECIATION, written off, viz :—			
16	Furniture, Fittings, etc. (10%)	14 8 6		
111	Show Plant (10%)	100 1 10		
2,101	Timber, Ironmongery and Miscellaneous Materials (20%)	2,100 18 11		
			2,215 9 3	
2,228				
267,798				269,276 8 2
	SPECIAL SHOW RESERVE FUND :			
	As at 31st December, 1944		5,175 15 0	
	Add : Amount transferred this year...		2,500 0 0	
			7,675 15 0	
	Less : Depreciation in market value of Investment		12 10 0	
5,176				7,663 5 0
	SUNDRY CREDITORS :—			
1,681	Sundry Accounts owing		2,200 1 2	
65	Subscriptions for 1946 received in 1945		113 1 3	
1,746				2,313 2 5
	Overdraft at Bankers on Investment Account at 31st December, 1945 ... ... [(Overdraft pending receipt of proceeds of sale of £6,568 17s. 9d. 2½% National War Bonds (1945-47), and £5,000 2½% National War Bonds (1946-48).]		11,607 2 8	
	Less : Cash at Bankers and in hand at 31st December, 1945 :—			
	Reserve Fund Account	498 2 1		
	Current Account	4,126 3 3		
	Petty Cash at Bank and in Hand	169 18 5		
		4,794 3 9		
	Show Account	767 11 9		
			5,561 15 6	
				6,045 7 2
£274,720				£285,298 2 9

Having examined the foregoing Statement of Receipts and Payments and Balance Sheet with the books and vouchers
actions of the Society for the year 1945 and that the Balance Sheet sets forth correctly its financial position on the 31st
the name of the Society or of Trustees on its behalf or, where the stocks are registered, that the certificates of titles were

Figures for 1944 £		£	s.	d.	£	s.	d.
	RESERVE FUND INVESTMENTS AT MARKET PRICES ON DECEMBER 31, 1945:—						
77,986	£73,571 11*s.* 9*d.* 3½% Conversion Stock (1961 or after) @ 106 ...	77,985	17	8			
2,997	£2,840 13*s.* 6*d.* London County 3½% Consolidated Stock (1958-68) @ 105	2,982	14	2			
12,969	£12,234 12*s.* 5*d.* Commonwealth of Australia 4% Registered Stock (1955-70) @ 106	12,968	13	11			
8,358	£8,316 1*s.* 3*d.* 3% Savings Bonds (1960-70) @ 101¼	8,420	0	3			
11,656	£11,371 18*s.* Commonwealth of Australia 3½% Registered Stock (1946-49) @ 101	11,485	12	4			
3,567	£3,430 Central Electricity Board 3½% Stock (1963-93) @ 104 ...	3,567	4	0			
5,097	£4,719 London, Midland & Scottish Rly. Co. 4% Debenture Stock @ 103	4,860	11	4			
31,571	£31,414 2*s.* 8*d.* 3% Funding Stock (1959-69) @ 101¼	31,806	16	2			
3,822	£3,784 9*s.* 10*d.* Croydon Corporation 3% Redeemable Stock (1956-8) @ 100½	3,803	8	3			
3,365	£3,416 8*s.* 4*d.* Railway Finance Corporation 2¾% Guaranteed Debenture Stock (1951-2) @ 98½	3,365	3	5			
3,000	£3,000 Eastbourne Waterworks Co. 4% Series "B" Mortgages @ 100 (cost)	3,000	0	0			
34,262	£34,433 18*s* 10*d.* 3% Redemption Stock (1986-96) @ 102	35,122	12	5			
25,983	£25,165 1*s.* 0*d.* 3% Conversion Stock (1948-53) @ 102¼	25,731	5	3			
2,274	684 Charrington & Co., Ltd. £1 Ordinary Shares @ £4 3s. 0d. ...	2,838	12	0			
798	760 Charrington & Co., Ltd. £1 4% Preference Shares @ £1 2s. 9d.	864	10	0			
9,326	£8,956 16*s.* 7*d.* 3½% War Stock (1952 or after) @ 103¼	9,247	18	6			
844	£827 4*s.* 4*d.* Western Australia Government 3½% Inscribed stock (1935-55) @ 101	835	9	9			
6,659	£6,568 17*s.* 9*d.* 2½% *National War Bonds* (1945-7)	.	.	.			
5,094	£5,000 2½% *National War Bonds* (1946-8)	.	.	.			
-	£1,600 3% Savings Bonds (1965-75 @ 101¾	1,628	0	0			
—	£1,100 3% Savings Bonds (1965-75) series "B" @ 100¾	1,108	5	0			
-	£11,607 2s. 8d. 3% Savings Bonds (1965-75) series "B" @ 100¾ ...	11,694	3	9			
					253,316	18	2
249,628							
	SPECIAL SHOW RESERVE FUND INVESTMENT:—						
5,176	£5,150 2½% National War Bonds (1952-54) @ 100½	5,175	15	0			
-	£2,500 2½% National War Bonds (1954-56) @ 99½	2,487	10	0			
					7,663	5	0
5,176							
144	FURNITURE, FITTINGS, FIXTURES, ETC. (*less* Depreciation) ...				129	16	3
1,500	PICTURES (£500) and BOOKS (£1,000)				1,500	0	0
777	PORTRAIT OF H.M. KING GEORGE VI.				777	10	0
1,001	SHOW PLANT (*less* Depreciation)				900	16	3
6,303	TIMBER, IRONMONGERY AND MISCELLANEOUS MATERIALS (*less* Depreciation)				4,201	17	10
2,789	EXPENDITURE ON SHOW AT LINCOLN				2,789	12	1
1,507	SUNDRY DEBTORS				788	12	11
57	RATES PAID IN ADVANCE				52	5	10
472	INCOME TAX RECOVERABLE				491	3	8
-	AMOUNT RECEIVABLE IN RESPECT OF SALES OF 2½% NATIONAL WAR BONDS				11,607	2	8
—	"ELEMENTS OF AGRICULTURE": Stock in hand (at cost) ...				1,079	2	1
	Cash at Bankers and in hand, 31st December, 1944:—						
858	*Reserve Fund Account*						
3,842	*Current Account*						
92	*Petty Cash at Bank and in Hand*						
4,792							
574	*Show Account*						
5,366							
£274,720	T. B. TURNER, *Secretary.*				£285,298	2	9

of the Society, we report to the Members of the Society that in our opinion the Statement truly sets forth the cash trans-
December, 1945. We have satisfied ourselves that the Society's Investments were at the close of the year duly inscribed in
then in the possession of the Society's Bankers.

PRICE, WATERHOUSE & CO.,
Chartered Accountants,

Royal Agricultural Society of England.

STATEMENTS RELATING TO FUNDS HELD BY THE SOCIETY IN TRUST OR WHICH ARE NOT CONSIDERED AVAILABLE FOR GENERAL PURPOSES.

RECEIPTS AND PAYMENTS ACCOUNTS FOR 1945.

E. H. HILLS' BEQUEST.

RECEIPTS.	£ s. d.	PAYMENTS.	£ s. d.
To Interest	240 10 10	By Grants to Cambridge University ..	240 10 10

QUEEN VICTORIA GIFTS FUND.

To Cash at Bank, January 1, 1945 ...	367 19 1	By Cash at Bank, December 31, 1945	519 2 1
,, Interest and Income Tax refunded	151 3 0		
	£519 2 1		£519 2 1

GILBEY FUND.

To Interest and Income Tax refunded	£43 14 4	By Grants to Cambridge University	£43 14 4

"MERCHANTS OF THE STAPLE OF ENGLAND" FUND.

To Cash with Society, January 1, 1945	81 3 5	By Cash with Society, December 31, 1945,	96 19 5
,, Interest and Income Tax refunded	15 16 0		
	£96 19 5		£96 19 5

CAPITAL STATEMENTS AT DECEMBER 31ST, 1945.

E. H. HILLS' BEQUEST.

	£ s. d.		£ s. d.
To amount bequeathed for Pot-culture Experiments	9,000 0 0	By £8,018 6s. 6d. 3% Redemption Stock (1986-96) at cost ... (*Market Value, December* 31, 1945, at 102—£8,178 13s. 10d.)	7,300 10 4
Less: Depreciation on and cost of conversion of Consols ...	3,717 2 6		
	5,282 17 6		
To surplus on sale of Stocks	2,017 12 10		
	£7,300 10 4		£7,300 10 4

STATEMENTS RELATING TO FUNDS HELD IN TRUST (*continued*).

CAPITAL STATEMENTS AT DECEMBER 31st., 1945.

Queen Victoria Gifts Fund.

	£	s.	d.		£	s.	d.
To Fund originally invested (the income from this Fund is used to make Annual Grants to unsuccessful applicants for pension through the Royal Agricultural Benevolent Institution) ...	5,000	0	0	By Investments in names of Trustees, at cost :—			
Less : Loss on sales of stocks	39	3	9	£1,089 1s. 3d. 3% Savings Bonds (1955-65) Series "A"	1,089	1	3
	4,960	16	3	£2,046 11s. 8d. Commonwealth of Australia 3½% Registered Stock, (1954-59)	2,099	18	10
.. Undistributed income . .	519	2	1	£1,000 London Midland & Scottish Railway Consolidated 4% Guaranteed Stock	1,556	15	9
				£190 4s 6d. 2½% Consols .. .	215	0	5
					4,960	16	3
				By Cash at Bank, December 31, 1945	519	2	1
	£5,479	18	4		£5,479	18	4

(The market values of the Stocks on December 31, 1945, amounted to £4,371 18 9).

Gilbey Fund.

	£	s.	d.		£	s.	d.
To Amount provided by the late Sir Walter Gilbey for endowment of Lectureship at Cambridge University	1,000	0	0	By Investment at cost . £1,457 5s. 2d. Metropolitan Water Board 3% (A) Stock (1963-2003)	1,204	10	4
.. Accumulation of Interest .	204	10	4	(*Market Value, December* 31, 1945, at 98½=£1,435 7 11).			
	£1,204	10	4		£1,204	10	4

"Merchants of the Staple of England" Fund.

	£	s.	d.		£	s.	d.
To capital sum paid by the "Merchants of the Staple of England" for the purpose of providing out of the yearly income Prizes to be competed for annually in the Wool Section of the Royal Show	500	0	0	By Investment at cost :— £526 11s. Commonwealth of Australia 3% Registered Stock (1955-58)	522	12	9
To bonus on conversion of original Stock	22	12	9	.. Cash with Society, December 31, 1945	96	19	5
.. undistributed income	96	19	5	(*Market Value of Stock, December* 31, 1945, at 100=£526 11 0).			
	£619	12	2		£619	12	2

Having examined the foregoing Statements of Trust Funds with the books and vouchers of the Society, we report to the Members of the Society that in our opinion the Statements truly set forth the transactions relating to these Funds during the year 1945 and the state of the Funds at the close of the year. We have satisfied ourselves that the Investments set forth were duly inscribed at the close of the year in the names of the Trustees or, where the stocks are registered, that the certificates of title were in the possession of the Society's bankers.

PRICE, WATERHOUSE & CO.,
Chartered Accountants,
Accountants and Auditors.

3, Frederick's Place,
Old Jewry, London, E.C.2.
15th February, 1946.

Royal Agricultural Society of England.

RECEIPTS AND PAYMENTS ON SHOW ACCOUNT.

1st January to 31st December, 1945.

Figures for 1944 £	RECEIPTS.	£ s. d.	£ s. d.
541	To Cash at Bank on 1st Jan., 1945 ...		574 4 8
13	,, Hire of Show Buildings		27 2 8
16	,, Interest received and Income Tax recovered on "Merchants of the Staple of England" Fund		15 16 0
	,, Amounts transferred from other Accounts :—		
1,350	Ordinary A/c.		1,500 0 0
£1,920			£2,117 3 4

Figures for 1944 £	PAYMENTS.	£ s. d.	£ s. d.
55	By Insurance of Plant, Cups and 3rd Party Risks	56 11 0	
54	,, Honorary Director's Expenses ..	66 0 9	
281	,, Surveyor's Half Salary and Expenses	278 9 6	
326	,, Clerk of Works' Salary, "Cost of living" bonus, and Expenses	428 10 6	
32	,, Contractor *re* Stock of Timber :— Compensation	32 10 0	
450	,, Contractor *re* Stock of Canvas :— Compensation	450 1 0	
24	*War Damage Insurance* ...	. . .	
8	,, Sundry Expenses	8 12 0	
116	,, *Fire-Watching on Society's Timber* ...	. . .	
-	,, Storm damage repairs	28 16 10	
1,346			1,849 11 7
574	,, Balance at Bank, Dec. 31, 1945		767 11 9
£1,920			£2,117 3 4

Examined, audited and found correct,

PRICE, WATERHOUSE & CO.,
Chartered Accountants,
Accountants and Auditors.

3, Frederick's Place,
Old Jewry, London, E.C.2.
15th February, 1946.

Royal Agricultural Society of England.

RESEARCH COMMITTEE.

RECEIPTS AND PAYMENTS FOR YEAR 1945.

Receipts.	£	s.	d.	Payments.	£	s.	d.
To Grant from General Account . .	630	0	0	By Grant to Rothamsted Experimental Station for Experiments *re* Cake Feeding on Grassland .	250	0	0
				,, Grant to Norfolk Agricultural Station for Experiments *re* disposal of Beet Tops and Straw	200	0	0
				,, *Farmer's Guide to Agricultural Research in* 1944 - Honoraria to Contributors	180	0	0
	£630	0	0		£630	0	0

Examined, audited and found correct,

PRICE, WATERHOUSE & CO.,

Chartered Accountants,

Accountants and Auditors.

3, Frederick's Place,

Old Jewry, London, E.C.2.

15th February, 1946.

Royal Agricultural Society of England

(*Established May 9th,* 1838, *as the* ENGLISH AGRICULTURAL SOCIETY, *and incorporated by Royal Charter on March 26th,* 1840).

Patron.

HIS MOST GRACIOUS MAJESTY THE KING.

President for 1946.

VISCOUNT BLEDISLOE, P.C., G.C.M.G., K.B.E.

Year when first elected on Council	Trustees.
1935	H.R.H. THE DUKE OF GLOUCESTER, K.G., *York House, St. James's Palace, S.W.1.*
1940	ATHLONE, Earl of, K.G., *Kensington Palace, S.W.*
1921-29 1935	BLEDISLOE, Viscount, P.C., G.C.M.G., K.B.E., *Lydney Park, Glos.*
1918	BURKE, SIR ROLAND, K.C.V.O., *Melton Mead, Woodbridge, Suffolk.*
1921	BURRELL, Sir MERRIK R., Bt., C.B.E., *Floodgates, West Grinstead.*
1921	COURTHOPE, Lord, P.C., M.C., *Whiligh, Walcrouch, Sussex.*
1911-17 1926	HASTINGS, Lord, *Melton Constable Park, Norfolk.*
1909	HAZLERIGG, Lord, *Noseley Hall, Leicester.*
1922	MILDMAY OF FLETE, Lord, P.C., *Flete, Ivybridge, Devon.*
1914	POWIS, Earl of, *Powis Castle, Welshpool, Mont.*
1934	STRADBROKE, Earl of, K.C.M.G., C.B., C.V.O., *Henham Hall, Wangford, Beccles.*
1925	WEIGALL, Lt.-Col. Sir ARCHIBALD G., Bt., K.C.M.G., *Englemere, Ascot, Berks.*

	Vice-Presidents.
1922	BELL, JOHN, *The Hall, Thirsk, Yorks.*
1938	CRANWORTH, Lord, M.C., *Grundisburgh Hall, Woodbridge, Suffolk.*
1908	DERBY, Earl of, K.G., *Knowsley, Prescot, Lancashire.*
1935	DIGBY, Lord, D.S.O., M.C., *Cerne Abbey, Dorchester.*
1913	EVENS, JOHN, *Burton, Lincoln.*
1936	EVERALL, WILLIAM, *Berwick Mount, Shrewsbury.*
1924	EVERARD, Sir W. LINDSAY, *Ratcliffe Hall, Leicester.*
1929	HAREWOOD, Earl of, K.G., *Harewood House, Leeds.*
1905	HARRIS, JOSEPH, *Brackenburgh Tower, Penrith, Cumberland.*
1942	NORFOLK, Duke of, K.G., *Arundel Castle, Sussex.*
1928	RADNOR, Earl of, *Longford Castle, Salisbury.*
1907	SMITH, FRED, *Deben Haugh, Woodbridge, Suffolk.*

	Ordinary Members of the Council.
1922	ALEXANDER, HUBERT, *Gileston Manor, St. Athan* (*Glamorgan*).
1939	ARGLES, CECIL G., *Sibson House, Wansford, Peterborough* (*Westmorland*).
1937	BAIRD, Capt. W. J., *Ranksborough Hall, Oakham* (*Rutland*).
1945	BARCLAY, Major M. E., *Beaches Manor, Brent Pelham, Buntingford* (*Hertfordshire*).
1937	BELCHER, J. MORRIS, *Tibberton Manor, Wellington* (*Shropshire*).
1930	BENYON, HENRY A., *Englefield House, near Reading* (*Berkshire*).
1939	BLEWITT, Lt.-Col. GUY, D.S.O., M.C., *Boxted Hall Farms, Colchester* (*Essex*).
1936	BOURNE, JOHN, *Snowshill Hill, Moreton-in-Marsh,* (*Gloucestershire*).
1931	BURRELL, Lt.-Col. WALTER R., M.B.E., T.D., *Knepp Castle, Horsham* (*Sussex*).
1936	CATOR, Lt.-Col. H. J., M.C., *Woodbastwick Hall, Norwich* (*Norfolk*).
1928	CHRISTY, Capt. HUGH A., *Llangoed, Llyswen, Breconshire* (*S. Wales*).

Year when first elected on Council	**Ordinary Members of the Council**—(*continued*).
1943	CORNWALLIS, Lord, K.B.E., M.C., *Plovers, Horsmonden, Paddockwood* (*Kent*).
1938	CULLIMORE, CHARLES, *Christleton, Chester* (*Cheshire*).
1921	*DAMPIER, Sir W. C. D., Sc.D., F.R.S., *Upwater Lodge, Cambridge.*
1942	DUBERLY, Capt. E. H. J., M.C., *Staughton Manor, St. Neots* (*Huntingdonshire*).
1927	DUGDALE, Major W. MARSHALL, D.S.O., *Pen Llwyn, Llanfyllin, Mont.* (*North Wales*).
1935	DYOTT, Major R. A., *The Manor of Freeford, Lichfield* (*Staffordshire*).
1936	EGERTON, Lt.-Commdr. H. SYDNEY, D.S.C., R.N., *Mountfield Court, Robertsbridge.* (*Sussex*).
1929	ELGIN, Earl of, K.T., *Broomhall, Dunfermline* (*Scotland*).
1933	EVERETT, Major NORMAN, *Rushmere, Ipswich* (*Suffolk*).
1928	FORSHAW, THOMAS, *The Stud, Carlton-on-Trent, Newark* (*Nottinghamshire*).
1935	FOSTER, Major GORDON B., *Leysthorpe, Oswaldkirk, York* (*Yorks., N. Riding*).
1922	GATES, B. J., *Pembury, Tring* (*Buckinghamshire*).
1931	GLOSSOP, C. W. H., M.P., *Bramwith Hall, near Doncaster* (*Yorks., W. Riding*).
1945	GRAFTON, Duke of, *Euston Hall, Thetford* (*Suffolk*).
1941	HADDON, R. W., C.B.E., *Dorset House, Stamford Street, S.E.1.* (*London*).
1925	HALE, WINDHAM E., *Grimsargh House, Grimsargh, Preston.*
1939	HARRIS, JOHN FREDERICK, *Brackenburgh Tower, Penrith* (*Cumberland*).
1945	HAZLERIGG, Major Hon. ARTHUR, *Noseley Hall, Leicester* (*Leicestershire*).
1919	HOBBS, ROBERT, *Kelmscott, Lechlade, Glos.* (*Oxfordshire*).
1942	HURD, ANTHONY R., M.P., *Rainscombe Farm, Oare, Marlborough* (*Wiltshire*).
1931	JERVOISE, Major F. H. T., *Herriard Park, Basingstoke* (*Hampshire*).
1923	JOHNSTONE, G. H., O.B.E., *Trewithen, Grampound Road* (*Cornwall*).
1932	KILPATRICK, JAMES, *Craigie Mains, Kilmarnock* (*Scotland*).
1944	LEIGH, Lord, *Stoneleigh Abbey, Kenilworth* (*Warwickshire*).
1940	MERSON, TOM H., *Farringdon, North Petherton, Bridgwater* (*Somerset*).
1943	MIDDLETON, Lord, *Birdsall House, Malton* (*Yorks., E. Riding*)
1927	*NEAME, THOMAS, *The Offices, Macknade, Faversham.*
1932	*NICHOLSON, A. C., *Trent Ironworks, Newark, Notts.*
1938	OSMOND, LESLIE K., *Barnoldby Hall, Barnoldby-le-Beck, Grimsby* (*Lincolnshire*).
1945	PEASE, Major PHILIP I., *Sledwich, Barnard Castle* (*Durham*).
1943	PENDER, Major H. DENISON, D.S.O., M.C., *Strangways, Marnhull, Sturminster Newton* (*Dorset*)
1935	ROBERTSON, WILLIAM, *Stamford, Alnwick* (*Northumberland*).
1937	ROBINSON, J. C. E., F.S.I., 15A, *St. Paul's Square, Bedford* (*Bedfordshire*).
1927	*RUSSELL, Sir JOHN, O.B.E., D.Sc., F.R.S., *Campsfield Wood, Woodstock, Oxfordshire.*
1931	SHELLEY, Sir JOHN F., Bt., *The Old Palace, Crediton* (*Devonshire*).
1933	STEDMAN, Sir L. FOSTER, *The Garth, Bassaleg, Newport* (*Monmouthshire*).
1938	STOPFORD-SACKVILLE, N. V., *Drayton House, Lowick, Kettering* (*Northamptonshire*).
1929	STRAFFORD, Earl of, *Wrotham Park, Barnet* (*Middlesex*).
1938	TALBOT-PONSONBY, A. H. B., *Hinton Woodlands, Bramdean, Alresford* (*Hampshire*).
1933	WALKER, Sir IAN, Bt., *Osmaston Manor, Derby* (*Derbyshire*).
1933	WALKER, JOHN, *Knightwick Manor, Worcester* (*Worcestershire*).
1943	WATNEY, BERTRAM W. A., *Brookwood Corner, Holmwood* (*Surrey*).
1929	WEBB, S. OWEN, *Streetly Hall, West Wickham* (*Cambridgeshire*).
1938	WIGLESWORTH, R. T., *Dene Croft, Chester Road, Mere, near Knutsford* (*Cheshire*).
1938	WRIGHT, R. K., *Kilkea, Mageney, Co. Kildare* (*Ireland*).

* Nominated Member of Council.

STANDING COMMITTEES.

*** Under Bye-Law 73, the PRESIDENT is a Member *ex officio* of all Committees, and the TRUSTEES and VICE-PRESIDENTS are Members *ex officio* of all Standing Committees except the Committee of Selection and General Purposes.

Finance Committee.

HAZLERIGG, Lord (*Chairman*)
RADNOR, Earl of
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
COURTHOPE, Lord
STEDMAN, Sir L. F.
WEIGALL, Sir ARCHIBALD
ALEXANDER, H.
BELL, JOHN
GLOSSOP, C. W. H.
TALBOT-PONSONBY, A. H. B.

Journal and Education Committee.

NEAME, T. (*Chairman*)
RADNOR, Earl of
HAZLERIGG, Lord
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
DAMPIER, Sir W. C. D.
RUSSELL, Sir JOHN
BURRELL, Lt.-Col. W. R.
DUGDALE, Major W. M.
GLOSSOP, C. W. H.

Chemical Committee.

GATES, B. J. (*Chairman*)
BLEDISLOE, Viscount
CRANWORTH, Lord
DAMPIER, Sir W. C. D.
RUSSELL, Sir JOHN
EVERETT, Major N.
HALE, W. E.
JERVOISE, Major F. H. T.
ROBERTSON, W.
ROBINSON, J. C. E.
SMITH, FRED

Botanical and Zoological (Forestry and Orchards) Committee.

HASTINGS, Lord (*Chairman*)
HAZLERIGG, Lord
BURKE, SIR ROLAND
COURTHOPE, Lord
BENYON, H. A.
BOURNE, JOHN
BURRELL, Lt.-Col. W. R.
CHRISTY, Capt. H. A.
DUGDALE, Major W. M.
GARDNER, R. C. B.
HENDERSON, J. K.
JERVOISE, Major F. H. T.
LE SUEUR, A. D. C.
NEAME, T.
TALBOT-PONSONBY, A. H. B.
THOMPSON, C. H.
WALKER, JOHN
WEETMAN, Col. W. C. C.
WIGLESWORTH, R. T.

Veterinary Committee.

BURRELL, Sir MERRIK (*Chairman*)
RADNOR, Earl of
DIGBY, Lord
MILDMAY OF FLETE, Lord
BURKE, Sir ROLAND
SHELLEY, Sir J. F.
STEDMAN, Sir L. F.
WEIGALL, Sir ARCHIBALD
BELL, JOHN
BLEWITT, Lt.-Col. GUY
BURRELL, Lt.-Col. W. R
BUXTON, Prof. J. BASIL
DUGDALE, Major W. M.
FOSTER, Major G. B.
GATES, B. J.
GLOSSOP, C. W. H.
HARRIS, JOSEPH
HARRIS, J. F.
HOBBS, ROBERT
JOHNSTONE, G. H.
ROBERTSON, W.
SMITH, FRED
WALKER, JOHN
WIGLESWORTH, R. T.

Committee of Selection and General Purposes.

COURTHOPE, Lord (*Chairman*)
THE PRESIDENT
MILDMAY OF FLETE, Lord
WEIGALL, Sir ARCHIBALD
SMITH, FRED

And the Chairman of each of the Standing Committees.

Research Committee.

DAMPIER, Sir W. C. D. (*Chairman*)
RADNOR, Earl of
BLEDISLOE, Viscount
CRANWORTH, Lord
HASTINGS, Lord
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
RUSSELL, Sir JOHN
BURRELL, Lt.-Col. W. R.
CATOR, Lt.-Col. H. J.
CULLIMORE, C.
DUGDALE, Major W. M.
DYOTT, Major R. A.
HOBBS, ROBERT
NEAME, T.
ROBINSON, J. C. E.
SMITH, FRED

Stock Prizes Committee.

FOSTER, Major G. B. (*Chairman*)
CRANWORTH, Lord
DIGBY, Lord
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
EVERARD, Sir LINDSAY
STEDMAN, Sir L. F.
WALKER, Sir IAN
WEIGALL, Sir ARCHIBALD
ALEXANDER, H.
BELCHER, J. MORRIS
BELL, JOHN
BLEWITT, Lt.-Col. GUY
EVENS, JOHN
EVERALL, WILLIAM
EVERETT, Major N.
FORSHAW, T.
GLOSSOP, C. W. H.
HARRIS, JOSEPH
HOBBS, ROBERT
KILPATRICK, JAMES
OSMOND, L. K.
ROBERTSON, W.
SMITH, FRED
WALKER, JOHN
WEBB, S. OWEN
The Stewards of Live Stock

Judges Selection Committee. -*Same as Stock Prizes Committee.*

Implement Committee.

BELL, JOHN (*Chairman*)
BURKE, Sir ROLAND
COURTHOPE, Lord
DAMPIER, Sir W. C. D.
STEDMAN, Sir L. F.
CATOR, Lt.-Col. H. J.
DYOTT, Major R. A.
EVENS, JOHN
EVERETT, Major N.
NICHOLSON, A. C.
OSMOND, L. K.
ROBERTSON, W.
WEBB, S. OWEN

Showyard Works Committee.

BURKE, Sir ROLAND (*Chairman*)
HAZLERIGG, Lord
BURRELL, Sir MERRIK
STEDMAN, SIR L. F.
BELL, JOHN
BLEWITT, Lt.-Col. GUY
BOURNE, JOHN
BURRELL, Lt.-Col. W. R
EVERETT, Major N.
FOSTER, Major G. B.
GLOSSOP, C. W. H.
HOBBS, ROBERT
NICHOLSON, A. C.
OSMOND, L. K.
TALBOT-PONSONBY, A. H. B
WEBB, S. OWEN

Dairy and Produce Committee.

BURKE, Sir ROLAND
BURRELL, Sir MERRIK
DAMPIER, Sir W. C. D.
WEIGALL, Sir ARCHIBALD
EVENS, JOHN
GLOSSOP, C. W. H.
JOHNSTONE, G. H.
KAY, Dr. H. D.
SMITH, FRED

Horticultural Committee.

HAZLERIGG, Lord (*Chairman*)
BURKE, Sir ROLAND

Honorary Director of Show. - SIR ROLAND BURKE, K.C.V.O.

Surveyor to Show.– CHARLES H. R. NAYLOR, *St. Mary's Chambers, Queen Street, Derby*

Society's Officers.

Secretary.--T. B. TURNER, M.V.O., 16, Bedford Square, London, W.C.1.

Editor of Journal.– DR. CHARLES CROWTHER, 79, *Cheam Road, Ewell, Surrey.*

Consulting Chemist.—ERIC VOELCKER, A.R.C.S., F.I.C., 1, *Tudor Street, London, E.C.4.*

Consulting Veterinary Surgeon. -Prof. J. BASIL BUXTON, M.A., F.R.C.V.S., *Royal Veterinary College.*

Publisher.- JOHN MURRAY, 50, *Albemarle Street, W.1.*

Solicitors.—GARRARD, WOLFE & CO., 18, *St. James's Place, S.W.1.*

Bankers.- WESTMINSTER BANK LTD., 1, *St. James's Square, S.W.1.*

INDEX TO VOLUME 106

1945

The titles of Articles are printed in Italics.

THE JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY OF ENGLAND

VOLUME 107.

1946

PRACTICE WITH SCIENCE

LONDON:

JOHN MURRAY, ALBEMARLE STREET


RANSOMES
PLOUGHS
First in Favour
By Appointment to H.M. King George VI.
Ransomes
EST. 1789
SIMS & JEFFERIES LTD.,
ORWELL WORKS, IPSWICH.

CONTENTS

Contents.

EXTRACT FROM THE SOCIETY'S BYE-LAWS

(*Dating from the Foundation of the Society*) :

"The Society will not be responsible for the accuracy of the statements or conclusions contained in the several papers in the Journal, the authors themselves being solely responsible."

PRESIDENT FOR 1947

LT.-COL. SIR ARCHIBALD WEIGALL, BT., K.C.M.G.

CROPS AND PLANT BREEDING

1. THE WORLD FOOD SHORTAGE.

Although it was quite clear during the latter part of the 1939-45 war that a world shortage of meat and dairy products, fats and sugar would be inevitable for some time after the cessation of hostilities, the vast extent of this shortage, with the additional burden of inadequate supplies of grain for human consumption, was not anticipated. An analysis of the causes of the present food position, with a statement by the Government of the steps taken to adjust its policy to the needs of this country and of the famine centres of the world, has been published in a White Paper (Ref. 1). The extremely serious state of world food supplies is due to the entirely inadequate production and reserves of grain, particularly wheat, rye and rice, resulting from droughts in the important producing countries, dislocation of agricultural economy and world trade, and devastation in the war zones. The production of wheat and rye in Europe was practically half in 1945 that of the pre-war average, supplies of rice in the important rice producing countries were similarly reduced, and there was a proportionate decline in the production of meat and other livestock products (Ref. 2).

The accumulated effects of this world-wide food shortage have resulted in a halt being called to the changes in agricultural policy of this country announced in the spring of 1945. These changes, although emphasising the necessity of maintaining the country's effort in wartime food production, envisaged greater attention being paid to livestock products, with a consequent reduction in the acreages devoted to cereals, potatoes, sugar beet and vegetables. It was proposed to expand the area of temporary grass by nearly 1,000,000 acres, to reduce the tillage by 650,000 acres, and maintain the acreage of fodder crops at its previous level. In place of these proposals, farmers have been warned that the tillage acreage must be restored to the 1945 dimensions, compulsory orders have been served to secure full acreages of beet and potatoes, and it is foreshadowed that the 1946-47 wheat acreage will be increased compulsorily to 2,500,000 acres. In addition, the extraction of flour has been increased to 85 per cent., bread has been rationed and concentrates to livestock have been drastically cut. Thus, the necessity of visualising and comprehending the world food supply as a single and gigantic problem affecting the agriculture of every individual nation is seen clearly. In particular, this country is peculiarly sensitive to world supplies and demands

of primary food products, and the inevitable consequences of the present situation is a continued concentration on crops for direct human consumption and for feeding to milking cows.

In June 1946 the Food and Agriculture Organisation of the United Nations published their report on urgent food problems which had been considered in a special meeting (Ref. 3). Among many recommendations, the more important affecting crop production and utilisation were—that each country should consider which of the primary food crops (grain, sugar beet, pulses, oilseeds or potatoes) will produce the maximum amount of food per acre for general distribution to consumers: that there should be co-operation to ensure adequate supplies of seeds: that during the present world grain shortage, the grain should be used so as to give the largest proportionate food energy value, and to do this there should be the greatest possible diversion from livestock to human consumption. Arising from the recommendations, it was advocated that the maximum use should be made of pasture, hay, straw and other bulky products and waste products for livestock; that dairy cows and draught animals should receive priority in any necessary feeding of coarse grains; that the feeding of grain to other classes of stock, especially pigs and poultry, should be reduced to a minimum: and that for the year 1946-7 extraction rates for wheat and rye should not be less than 85 per cent., and wheat flour should be supplemented to at least 5 per cent. by other grain products, potato flour, etc. The matter of the composition of the loaf had been dealt with by a special committee in this country (Ref. 4).

The far-reaching agricultural implications of these recommendations need no emphasis for the farmer, although the F.A.O. recognises that when the more immediate and pressing shortages have been overcome, a change in policy will be necessary. It is stressed that "short-term objectives must be achieved with the least possible prejudice to long-term policy and general economic rehabilitation." It is visualised, for example, that it is urgent that countries should return as soon as possible to more balanced farming with a greater variety of crops and that as soon as grain supplies are available, special consideration should be given to countries which have suffered most severely from depletion of their stocks and herds. In the meantime, with an eye always on the transition, agriculture must concentrate on the immediate necessity of avoiding famine and starvation for human beings.

2. THE GRASS LEY.

a. Establishment. The establishment and maintenance of leys must continue to be one of the most important aspects of crop and animal husbandry in this country if the productivity of agriculture is to be maintained at a high level. It is maintained by some farmers in arable districts that ley farming will prove to be the only means by which sheep can be restored to their pre-war numbers, and the fertility of the land replenished (Ref. 5). It is maintained that some system of combining sheep ranching and corn production will extend, and that arable sheep-farming in conjunction with ley grazing will prove to be an expanding practice. Similar combinations of intensive arable farming, involving the cultivation of cereals, potatoes, sugar beet and forage crops, with specialised leys for rotational grazing, will prove necessary for the production of human food and adequate stocks of food for the cattle population which is visualised.

Jenkin (Ref. 6) has pointed out that the essential difference between the new ley farming and the old is that, under the new system, the whole object is to improve the sward during its life, and not to visualise a steady deterioration until ultimately the plough is taken in. Leys managed on this principle not only ensure greater stock-carrying capacity, but when ploughed up in first-class condition, are the finest preparation for arable crops and serve as the basis for increased crop production. Where leys are of the longer duration type, as for example in the western parts of the country, it is essential to use herbage plant species

and strains of the more persistent type, and the character of the seeds employed, with the emphasis on leafiness and persistence, is the foundation of the new system of ley farming and a pre-requisite for its success.

It is sometimes assumed that the inclusion of a good strain of wild white clover is the most important, or even the only, requirement of a good seeds mixture for a long ley, the grass strains being of comparative insignificance provided the wild white clover has received attention. Jenkin draws attention to the incorrectness of this attitude, and states that wild white clover does not increase the persistency of the grasses, and a high productivity long-term sward cannot be successfully maintained if the grass strains are poorly adapted to the conditions and form of management. Indeed, it is true to say that the inclusion of persistent grass strains is more important than the wild white clover, because the grasses must constitute the main feature of the sward, and will give it its chief characteristics, while under good conditions and management there is liable to be considerable natural colonisation by wild white clover. Provided the seeds mixture makes it possible to establish and maintain a dense and lasting sward, the foundation has been laid for achieving a higher level of grassland productivity during the life of the ley, which is an essential requirement of the new system of ley farming.

The important practical problems in relation to the establishment and early management of sown pastures in this and other countries are described and discussed in a special bulletin published by the Imperial Agricultural Bureaux (Ref. 7), and also for conditions in Wales by Griffith in Ref. 8. From the agriculturist's point of view, the main considerations included in the establishment of a ley are pre-cultivations and soil preparation, manuring, sowing, cultivations after sowing, the use of a nurse crop and the seeds mixture. Establishment may also be said to include the early management of the ley, because no matter how skilfully or successfully may the initial preparations and actual sowing be carried out, these may be largely nullified by mismanagement in the first year.

The detailed questions of crop husbandry discussed by the various grassland authorities of this country in the references here given, cannot be considered fully, but some of the more practical aspects of the problem as they affect general procedure can be alluded to briefly. In describing the problems of the establishment of the ley in Britain, William Davies (Ref. 7) asserts that in the higher rainfall areas (which for practical purposes may be taken as those areas receiving an average rainfall of 30 inches or more) the initial establishment of sown grass and clover seeds "presents little or no difficulty, provided the normal tenets of good husbandry are followed." In the lower rainfall parts of east and south England, although there are greater difficulties, recent research has demonstrated that seeds may be established with equal assurance provided certain extra precautions are taken.

The more or less general application of the principle that the land must be well prepared, fully consolidated to plough depth and with a good surface tilth, is now accepted as a necessary condition for a good "take" of sown seeds. With regard to the more controversial matters of the method and depth of sowing, recent evidence is supplying more exact information on the factors deciding the best procedure. It appears that the depth at which the seeds are sown is one of the most critical considerations, and while in districts characterised by an adequate summer rainfall broadcasting and covering to a depth of a quarter to half an inch with light harrows is sufficient, in the lower rainfall areas there is considerably less risk of a poor "take" if a drill is used and the seeds buried to a depth of approximately one inch. In high rainfall areas, drilling does not seem to have any advantages over broadcasting, while under all circumstances drilling has the great disadvantage of leaving bare soil between the drills which is subject to weed infestation. This can be overcome to some extent by including wild white clover in the mixture, while there are distinct possibilities in the use of special seed drills which will sow at narrower spacing.

The method of sowing is obviously bound up with the time of sowing, and although the spring is for most circumstances the most suitable season, it is usually desirable to sow more deeply if this time is chosen, particularly in the drier parts of the country. Early spring sowing should, therefore, be the usual choice, and early autumn or late summer may prove virtually as successful. In high rainfall districts the choice of season is wider than where the rainfall is low, but even under the most favourable climates for herbage plants, late spring or late autumn sowings are not advisable. It should be remembered, also, that the kind of seeds mixture will determine to some extent the liberties that may be taken with regard to sowing date. Grasses, particularly the more vigorous species such as rye grasses, cocksfoot and timothy, have a wider range of sowing dates than the clovers, which are the most liable to fail from late sowing in the autumn, and a useful addition to the knowledge of ley establishment would result if a technique could be devised for establishing the leguminous portion of the seeds mixture in an established young grass sward.

Although for economic reasons and, particularly in the case of short leys composed of quickly growing and rapidly establishing grasses and clovers, it has been the general practice to sow such mixtures in this country under a cereal nurse crop, this practice is not generally advocated by Davies. In particular, in the case of long duration grazing leys, the best method is to sow without a nurse crop, or to undersow in a cereal or other crop which will be grazed as soon as there is available keep on it. Although under some conditions, the nurse crop can protect the grass and clover seedlings from being burnt out by hot sun, there is no doubt that harm is usually done by the nurse crop unless it is itself grazed while the herbage plant seedlings are establishing themselves.

The decision whether or not to use a nurse crop, and if a nurse crop is decided upon what kind to use, is all-important for the establishment of the ley because it determines the management in the seeding year. If a cereal for grain is used as a nurse, there is little to be done before the crop is harvested, and the young ley is left to fend for itself until the late summer or autumn. If sown under a silage mixture, there is an opportunity to commence suitable ley management considerably earlier to the benefit of the sward. When a nurse crop for grazing is used, controlled grazing may commence from three to four weeks after sowing, and the land is virtually in use all the time. Under suitable conditions for sowing without a nurse crop, or for using Italian rye grass in this rôle, the ley may be grazed from five to twelve weeks after sowing, and the establishment can usually be regarded as the least subject to the dangers causing failure. This question of the time between sowing and grazing is most important, and it has been found that the best results are obtained when grazing is effected at the earliest opportunity, with as many head of stock as is possible to eat off the herbage as quickly as can be managed. The action of the grazing animal in consolidating the land is more effective than any form of rolling by implements yet tried.

If the young ley is sown and managed so as to allow controlled grazing in the seeding year, it may become virtually fully established before the winter, but care should always be taken to leave the sward in good condition for the first overwintering. In the first harvest year the usual procedure is to take hay, and while this is allowable in the case of hay leys, it should be avoided for all pasture leys, particularly the long term ones. There are no exceptions to the rule that long term grazing leys should be grazed and rested on a rotational and systematic method if the sward is to develop into a persistent and highly productive unit. The most suitable method of grazing will depend on the botanical composition of the sward, particularly the grass-clover ratio and the dominant grass species, and the special purpose for which the ley was sown.

It is, of course, difficult to lay down hard and fast rules for universal application to the most appropriate methods of ley establishment and early management, but the general principles are becoming increasingly apparent as research work proceeds on these problems.

Fertiliser treatment, with the outstanding importance of lime and phosphate for good establishment, coupled with the stimulating effect of nitrogen, are of more or less general application. In this connection, it has been found in recent years that the placement of the fertilisers at sowing is important. Experiments with combine drills suggest that there is much to be gained in the initial establishment of the ley by applying fertilisers to the soil immediately in contact with the seed, and that in the case of phosphates, there is less tendency for them to revert so rapidly in the soil.

Particular conditions may require special treatment with regard to ley establishment and early management, and details of these and of certain technical points may be found in Refs. 7, 8 and 9 which include conditions in Scotland and Wales as well as in England. The factors affecting long-term productivity on acid upland soils are dealt with in Ref. 9, which is particularly interesting in drawing attention to the distinct effect of management under different conditions. The striking effect on productivity from liming, manuring, cultivating and sowing grass and clover seeds under acid upland conditions, with the increased yields of dry matter, protein, lime and phosphate resulting from the addition of limestone and phosphatic dressings to seeded areas, are matters of fundamental interest and importance to grassland husbandry. In Ref. 17 an account is given of reseeding in East Anglia, and it is significant that direct reseeding is advocated in preference to sowing under a cover crop.

The extremely important practical nature of these problems in connection with ley establishment may be seen from an analysis of twelve years' records on the effect of the nurse crop on farms in Yorkshire (Ref. 18). Failure to obtain a good " take " of sown seeds was one of the commonest complaints experienced in dealing with cropping and grassland problems in this county, and although other causes, such as inadequate fertiliser applications, bad dressings and poor cultivations were apparent, the effect of the nurse crop was most significant.

One of the most striking features of this analysis was that of the total number of cases studied of seeds sown with a nurse crop, over 22 per cent. showed poor " takes," and 34 per cent. were only moderate. The reasons for this unsatisfactory result are ascribed to the action of the nurse crop to a large extent, because 46 per cent. of the poor " takes " appeared to be due to competition from the nurse crop, and 27 per cent. to lodged cereal crops. This supports the view which is gaining ground among farmers that to ensure successful establishment of long leys it is worth sacrificing the nurse crop and concentrating on obtaining early grazing by sowing the seeds alone, or with Italian rye grass or rape.

b. Nutritive Value. The results of research work on ley farming in Sweden are of direct practical interest to agriculture in this country, because the Swedes are faced with very similar problems to ours, and in some aspects of the work they are the leading authorities. In a recent account of Swedish investigations, the main emphasis is placed on the amount and quality of the forage obtained from grassland, and the means by which both of these may be improved (Ref. 10). Swedish cattle farming, and dairy industry, are directly dependent on ley farming, and 42 per cent. of the arable land is used as hay leys, although there is in addition an area of natural meadow equivalent approximately to 60 per cent. of the ley acreage. The true economic value of these two main types of grassland may be judged from the assessment made of their yields in food units and digestible protein, the leys being calculated to give 3,000 million food units a year containing 400,000 tons of digestible protein, and the natural meadow land 700 million food units with nearly 60,000 tons of digestible protein. Before the war Sweden imported 400 million food units as oil cakes.

The tremendous contribution of the leys compared with the other sources of food for livestock is clearly shown from these figures, and in particular the relatively high pro-

ductivity of ley grassland compared with natural meadows is strikingly demonstrated. Acre for acre the ley grassland supplies not only more food units, but also very much more digestible protein, and the maintenance of Sweden's position in regard to the country's milk supply is ascribed to the considerable development of pasture cultivation. Considerable concern is felt, however, by Swedish agricultural authorities, concerning the supply of winter fodder of adequate quality to maintain winter milk production of good vitamin A content. The aim is to provide sufficient home-grown winter fodder of such quality as to be able to dispense with imported oil cakes. For this purpose, research is being intensified on methods of fodder conservation, and in particular methods of making silage are being studied. It has been found that A.I.V. silage gives a fodder of sufficient protein and dry matter content to maintain a satisfactory milk production, and the carotene content is preserved and stored with very small loss.

The whole problem of the content of "protective" nutrient substances in home-produced fodder, particularly of herbage plants, is receiving attention in Sweden. The question is important in affecting the health and productive capacity of farm livestock, as well as having a material influence on the value to human beings of the live-stock products. Although the carotene content of herbage plants depends on their stage of development and the season of the year, and whether consumed as pasture or hay, there is considerable variation between different species. In the Swedish experiments, white clover showed the highest carotene content in both the pasture and hay stage, being slightly higher than in red clover, and distinctly higher than in the grasses studied. Both Swedish and Danish experiments have also demonstrated that grass species show different carotene content at comparable stages of growth, the Danish work putting cocksfoot above rye grass, timothy and meadow fescue, and the Swedish results pointing to rye grass being much inferior to smooth stalked meadow grass.

It is possible to conclude from other investigations that as the dry matter of herbage plants increases, the carotene content decreases. The protein content also follows definite relationship with the stage of development, being high with high carotene, and low with high dry matter. It may be seen from these associations how significant for the feeding value of herbage fodder is the botanical composition and stage of development. The proportion of leaf to stem, the rate of hard to soft tissue, and the mixture of herbage plants in terms of grasses and clovers and the particular species of each, are basic considerations in determining nutritive value. It should be realised also that the taste and aroma of milk, and the consistency of butter, are naturally affected by the grass-clover ratio of the herbage, while the vitamin D content is higher during the summer grazing than during winter feeding. In order to make the utmost use of grassland fodder, therefore, it is necessary not only to ensure that the grazing animal is offered the best mixture of herbage plants in the most nutritious and palatable condition, but also that fodder conservation for winter feeding is carried out in the most efficient manner.

c. Seasonal Growth. Important observations on the seasonal growth of pastures are also included in Ref. 10. The commonly occurring circumstances in pastures are that the amount of growth increases from early spring until it reaches a maximum round about midsummer, and then there is a marked depression of growth which is followed by a second flush corresponding to the aftermath flush. The problem in many pastures is to even out the two peaks of growth and eliminate as far as possible the "hungry" intervening period. The Swedish observations suggest that the water supply in the soil has a marked effect on the seasonal growth of pastures, and that when there is a fairly high ground-water level, the depression is less marked and a larger part of the total season's production is postponed until the height and later part of the summer. Experiments with nitrogenous manuring also indicated that similar results could be obtained by suitable applications of

fertiliser at the appropriate time, particularly when growth begins early and total production is therefore comparatively large. On the other hand, the depression of growth was more marked under some conditions when the pasture had received nitrogenous dressings, particularly on nutrient-deficient peat soils.

Seasonal productivity of pastures is affected very much by major climatic factors which determine the rhythm of growth of the grasses. Under conditions when growth starts late, and the smaller period of vegetative growth occurs before midsummer, the midsummer depression does not occur, but is replaced by a steadily declining rate of growth without any second peak. The occurrence or absence of the depression is then probably connected with the physiological condition of the plants as related to their stage of development and the growing conditions, while the micro-biological status of the soil may also play a part. The really significant practical consideration is, however, control of seasonal growth of pastures and must be considered in relation to climate, manuring, management and the species of herbage plants in the sward.

3. STRAINS OF CLOVER.

a. Red Clover. A useful account and analysis of the behaviour and agricultural virtues of the different strains of red and white clover is given in Ref. 11. The wide adaptability of red clover has resulted in this leguminous herbage plant being grown in many temperate countries of the world, and there are available not only strains of different nationalities, but also local strains within certain of the nationality types. In addition, bred strains have been developed in this and other countries, thus adding to the many forms. Although during the 1939-45 war there was a great reduction and restriction in the number of strains available, it is probable that in the future foreign strains will again be on the market. Therefore, owing to the great importance of red clover in mixtures for short leys, some idea of the relative value of the more important strains is essential for the grower.

The value of early red flowering strains should be assessed primarily on their productivity in the first harvest year, when they are at their best, although if in addition to being up to the best standard in the first harvest year, a strain is capable of contributing to the winter keep and the early spring growth and hay crop of the second harvest year, it is particularly valuable. American Medium from the Northern States is the only foreign strain comparable in yield to the native strains of this country, but it is less valuable because of its extreme hairiness. Of the other foreign strains, those from New Zealand, Canada, Switzerland, Czecho-Slovakia and Denmark are superior to strains from most of the other countries, but are still not equal to English broad red, which in its various strains shows a wide adaptability to this country and is outstanding for its contribution to winter and early spring keep. The bred strain S. 151 is slightly later than English broad red, but is capable of persisting more satisfactorily into the second harvest year, as also is Vale of Clwyd, which, however, is appreciably later in flowering.

The most important agricultural character of the late flowering clovers is their persistency, although the first harvest year yield is of considerable significance. The north European strains are unsuitable for conditions in this country because of their lateness in spring and short growing season, the latter character and hairiness being a defect of American Mammoth. The best foreign late strains, though still inferior to the native strains of this country, are the south Swedish and Danish. English late flowering red clover exists in a number of local strains, has a wide range of adaptability, and is characterised by greater earliness and less persistence than some of the other native lates. Montgomery and Cornish Marl are very similar in their main characteristics, and are valued chiefly for their persistence and yielding capacity under grazing: their chief disadvantage is lateness in spring. The bred strain S. 123 has a similar disadvantage, but it is an im-

provement on the other two strains in yield and persistency, and like them can withstand severe defoliation resulting from heavy grazing.

b. White Clover. White Clover exists in several types and many strains, some of which are " native " and others foreign. The major agricultural distinction is that between the true wild white strains, and the ordinary, or as they are sometimes called, the " cultivated," strains. The true wild white strains are indigenous, while the ordinary white are of varying origin, some being foreign commercial, others foreign bred, while one only has been bred in this country from plants of foreign and native origin. As a matter of general policy, the ordinary white strains are utilised for the shorter leys, and the wild whites for long duration leys.

The common forms of ordinary white clover used in this country are the Dutch white, New Zealand Mother and New Zealand Permanent Pasture, and the newer-bred strain S. 100. A small amount of the Danish Morsø and Strying strains, and the Italian Ladino white clover, is also grown. The Dutch White has been used extensively and with considerable success in various parts of the country, and the stocks are of varying origin, the seed being grown in various continental countries, the U.S.A., and the eastern parts of England. The type is suited to the shortest leys in which white clover is used, and in general cannot be expected to persist in any great amount for more than a few years. The New Zealand certified white clovers are the best of the imported types, being more vigorous, productive and persistent than the Dutch white. New Zealand Certified Mother is larger leaved and less persistent, while the Permanent Pasture is intermediate between the Mother and the English wild white. The bred strain S.100 has introduced a new standard in white clovers. It combines a high productivity in the early years from sowing, being superior to all other strains in this respect, with an unusually long persistence for a white clover. S.100 has a long growing season, and its introduction to British agriculture with the availability of New Zealand Mother as a good substitute, make it in general unnecessary to use large amounts of foreign strains in this country.

The principal characteristics of wild white clover, which exists in many strains, are its extreme persistency, its capacity to maintain itself under comparatively poor conditions, and its suitability for close grazing, although it is apt to suffer to a relatively greater extent than white clover from severe defoliation. For the most part, wild white clover shows its superiority to ordinary white clover after the fourth or fifth years, and this superiority becomes more pronounced as the ley becomes older. The bred strain S. 184 is denser and more uniform than the unselected strains of wild white clover, and in some trials has consistently proved superior to English wild white. It is recommended that S. 184 should replace the commercial wild white for long leys, and for relatively short leys on the poorer soils. On the other hand, there is much to be said for blending S.100 and S.184 or English wild white for the establishment of long leys, such a procedure ensuring a better contribution of the clover in the early years.

A proper understanding of the principal characteristics of the main types and strains of red and white clover is essential for their intelligent utilisation. It is probable that foreign stocks will become available in the not too distant future, and the grower should have a clear idea as to what is known of the relative merits of the types and strains of various origin. Differences in the price of the seed of some strains is sometimes by no means inconsiderable, and while cheapness of seed is often false economy, the grower needs to be assured that additional expense is justifiable on his part.

4. GRASSLAND IMPROVEMENT.

Some general problems concerned with grassland deterioration and improvement in Scotland are discussed in Ref. 12, and as these considerations have more than a local appli-

cation, they are worth mention here. The maladjustment of grazing, resulting from a type of ranching, which in parts has replaced a nicely balanced agricultural system, has led to the disappearance of many of the valuable grazing species and the encroachment by inferior or worthless plants. The ill-effects of the bad management, and the change in the botanical composition of the grassland, are the chief causes of deterioration, and the relegation of much farming land to the marginal category. In the course of time the poor condition of much of the permanent grassland of the country has come to be regarded as a symptom of old age, whereas the true cause is the poor botanical composition resulting from mismanagement. Deterioration is not an inevitable accompaniment of ageing in pastures, but rather should it be considered that productivity can be steadily improved by good management. This, as has been mentioned at the beginning of this article, is the object of efficient ley farming.

It has now been amply demonstrated that the poor condition of much of the rough grazings is due primarily to lack of lime and phosphates combined with bad management. Similarly it has been shown that improvement is dependent on the elimination, as quickly as possible, of the inferior plant species and their replacement by valuable species which must be maintained in sufficient amounts. This can be done by ploughing and reseeding in a large number of cases, and the degree of improvement will be in proportion to the poorness of the grazing when it is taken in hand. There is in Scotland, however, a very much more important aspect of pasture improvement simply by taking advantage of the large amount of useful summer grazing that is available over a considerable acreage. But it is necessary to have livestock in sufficient numbers to make full use of the herbage at the right time.

There are certain types of hill grazings that produce excellent keep for a short period during the summer months, but which are very poor for the rest of the year. These can be improved considerably by moving stock on to them at the appropriate time, and removing the stock when growth finishes. But the limiting factor to this type of improvement is that there is usually a lack of winter feed elsewhere on the farm to maintain a sufficient head of stock for grazing the larger summer areas. It becomes necessary, therefore, to improve by ploughing and reseeding small areas in protected localities to provide sufficient winter feed for the animals which will be run on the extensive summer grazings and thereby improve their carrying capacity.

The two methods, as applied to hill farming areas, are therefore complementary. The improvement under an intensive system of a small suitable area makes it possible to overwinter more stock which can then be used to improve the rough grazings by controlled summer management. The summer management of the small reseeded area is important, because on its condition will depend the possibility of overwintering the sheep that will be brought down from rough grazings. It has been found that the use of cattle for controlled summer grazing on the reseeded area proves to be a satisfactory method of ensuring a pasture in good winter condition for the sheep. These cattle can be grazed on the rough grazings from mid-August to mid-May, and used on the improved seeded pasture for the three summer months while the sheep are away.

With regard to seeding out poor land at high elevations in Scotland, it is reported by a farmer who has experimented with seeds mixtures that the most satisfactory suppression of such weeds as couch, Agrostis and Yorkshire fog is best achieved by a sward dominated by cocksfoot and tall fescue (Ref. 14). Although the mixture was very heavy, being at the rate of 55¾ lb. to the acre and including 8 grasses and 6 clovers, the cocksfoot and tall fescue contributed 15 lb. each, and therefore far outweighed any other constituent. The good results of the mixture are explained as due to this fact, and also the relegation of the rye grasses to a mere 4 lb. of perennial and 2 lb. of Italian, because it is claimed that these latter grasses appear to have no weed suppressing powers.

5. CEREALS.

a. The Use of Immature Grain for Seed. While the stage of ripening or maturation of grain at harvesting has a great significance for the utilisation of the crop from the consumer's point of view, different criteria are necessary when the grain is to be used as seed. Barley for malting and brewing, wheat for bread-making or biscuit manufacture, and oats for feeding or milling, as well as rye for milling or as a livestock feed, are all subject to a greater or less extent to variation in suitability for their particular form of utilisation by the ripeness and maturity of the grain when the crop is cut. Most of the considerations involved in the criteria of assessing the quality of the grain of these cereals for the various methods of utilisation have little application to the problems of producing a sample of seed.

The effect of using seed harvested prematurely, or at all events in a condition which would be considered as not ripe when judged on commercial standards, has been the subject of experimentations from time to time, and recent work with wheat, barley and rye has yielded additional information (Ref. 13). Pot culture experiments with these three cereals have demonstrated that even with very immature grain, successful fulfilment of the life-cycle is obtained, and the plants from immature grains have a higher relative growth rate than do plants from mature grains. This point was also demonstrated by a small scale field trial with winter rye, and grain harvested as early as 5 days after fertilisation germinated readily and produced normal plants, even though the grain size was only 10 per cent. of a fully developed grain. A comparison of the field behaviour of seed harvested 20, 30 and 44 days after fertilisation, showed good germination and overwintering of the immature-grain plants, although with close spacing the percentage survival was somewhat reduced. It was also found that with moderate spacing the yield decreased with the size of grain sown, but as the sowing rate was increased, the difference between the mature grain and the other grain sizes became smaller. Consequently, the smaller the grain the denser is the rate of sowing necessary to give comparable yields from mature grain

b. Spring Wheat and Barley Trials. Although autumn sowing of winter wheat varieties commonly results in heavier yields than from spring wheat cultivation, there are conditions, particularly under present circumstances, when the use of spring wheats is desirable if not necessary. Reports of trials with spring wheats are not numerous, and the account given in Ref. 19 of 4 years' trials in North Wales is consequently of special interest. In this district it is usually not possible to sow before the second or third week of April, the rainfall is high and the corn is apt to lodge, while the comparatively short growing season demands early ripening varieties.

The wheat varieties tested were April Bearded, Diamond II, Meteor, Fylgia, Atle and Extra Kolben II, the first named being the old established variety for April sowings and acting as the standard or control for the four years' trials. The results indicate that all the new varieties, except Meteor in one year, gave slightly higher yields than April Bearded, and although the experiments did not lend themselves to statistical analysis, the results obtained were fairly consistent from year to year. With regard to time of ripening, it was observed that Diamond II, Fylgia and Meteor were similar to April Bearded, while Atle and Extra Kolben II were later and are probably suited better to March sowings in North Wales—as they are in other districts. In spite of the fact that the growth was not sufficiently vigorous, or the yields sufficiently heavy, to test the standing capacity of these varieties really thoroughly, all the new varieties appeared to have stronger straw than April Bearded, while Atle was markedly superior in this respect.

The four varieties of spring barley tested were Plumage Archer, Abed Kenia, Camton and Maltster, the first named variety being the control variety used for comparison. Only two years' trials are recorded; in the first year Abed Kenia was tried against Plumage-Archer, and in the second year all four varieties were included. Abed Kenia proved to be

a higher yielder than Plumage-Archer in both years, while it was shorter in the straw and ripened earlier. There was a suggestion that Maltster was capable of higher yields than Plumage-Archer, while Camton was equal to the latter variety in total grain yield, but had a considerably lower amount of tail corn. It should be pointed out, however, that none of the varieties tested gives such high quality malting barley as Plumage-Archer, although Maltster gives good samples in some districts. Kenia is not popular with maltsters in this country, while Camton was not bred as a malting barley and should not be judged on commercial standards for this purpose.

6. POTATOES.

a. The Occurrence of "Sports" in Potato Stocks. The presence of "sports" or variations in potato stocks is undesirable for two reasons: they may adversely affect the yield, and they may be responsible for undesirable tuber characters. Also, when they occur in too high a proportion they produce an impure stock which is no longer true to the varietal type, and consequently are responsible for reducing the economic value of that stock. The only known satisfactory way of eliminating "sports" is by roguing, which to be efficient must be continued throughout the growing season if all undesirable plants are to be removed. Small nursery stocks can also be grown and kept under careful observation to act as a nucleus for building up new stocks, but this can only be done if the farm is so situated that healthy stocks can be grown. As a longer term means of attacking the problem, there is also the possibility of breeding stable varieties, because it is known that there is considerable difference between varieties in the tendency to produce "sports."

Of the variations that affect yield, the important ones are Bolters, Semi-Bolters, Wildings, Feathery Wildings and various other foliage variations. Bolters and Semi-Bolters are most common in early varieties, but occur also in maincrops, and are apt to be found more frequently in some varieties than others (Ref. 15). Wildings and Feathery Wildings are common to all varieties, and are as frequent in maincrop as early varieties, while the various other foliage variations are a heterogeneous group that cannot be accurately classified. Bolters are the only type of variation which appear to affect disease resistance, the plants showing a greater resistance to Blight, but this may simply be due to their later maturity.

Very little work has been done on the yielding capacity of these variations compared with that of normal plants lifted at the same time, but some data are given on this important point in Ref. 15. In an experiment to test Bolters and Semi-Bolters lifted at two different dates—17th July and 4th October—it was found that both of these variations tended to be lower yielding than normal plants at the early lifting, but at the October lifting there was little difference. This experiment with the variety Arran Pilot is supported by experience in the field with early varieties, and although the yield from Bolters and Semi-Bolters may be greater than that from normal plants at maturity in the case of Arran Pilot, the yield of early varieties grown for early use may suffer if there is a large number of these two types of variations. It has also been demonstrated that the yield from various types of Wildings and from Feathery Wildings in the variety Kerr's Pink is below that of normal plants, and that as yet no type of variation has been found that outyields the normal plants of the same variety while still retaining the same date of maturity.

It is important to realise that once variations have appeared in a stock, certain conditions and practices tend to restrict their multiplication, while others tend to accelerate it. For example, the use of chats as seed increases considerably the number of Wildings, Feathery Wildings and other variations characterised by the production of small tubers. Any practice which makes recognition and roguing difficult causes an increase in variations, as for example, bad earthing up, the use of uneven size of seed, and the spraying of tops to

kill before lifting. Conversely, the avoidance of such practices, rigorous roguing through the season, or the growing of carefully controlled nursery stocks all act to prevent or control the multiplication of undesirable variations.

b. Diseased Conditions associated with Mineral Deficiencies. Failure of the potato crop associated with diseased conditions of the tops has been found in parts of Scotland to be due to deficiencies in the minerals calcium, magnesium or nitrogen (Ref. 16). On certain very acid soils the haulm grew to only six inches, the older leaves had yellow and brown blotches with dead patches, the younger leaves were of a pale, unhealthy green, and the tubers were small and of a low yield. This condition was found to be associated with a marked calcium deficiency in the leaves, probably also aggravated by a deficiency of magnesium, because this element was also lower than in healthy plants. A dressing of 6 cwt. to the acre of potato manure did not correct the trouble, but where lime, lime and dung, or dung alone were applied, there was healthy growth and a fair yiel' of tubers.

A second diseased condition was studied in another area where the crop showed poor growth of the haulm and premature shedding of the leaves in spite of the fact that an adequate dressing of potato manure had been given. In the early stages of the condition the leaves of the plants showed an upward curling, and at a late period the edges and tips of the leaves became yellow. These symptoms were followed by extensive development of an orange-yellow colour, usually accompanied by brownish-purple areas and dead brown patches. At the end of the season these plants showed a considerable reduction in yield. When all the leaves were tested they were found to be very deficient in magnesium, as also was the very acid soil in which they were growing. The most effective means of correcting this deficiency was found to be by applying lime, particularly a dolomite limestone which contains magnesium, or by adding dung. Alternatively, a suitable soil dressing of magnesium salts would serve the purpose.

Both the conditions just described were associated with extreme soil acidity, and lime and dung are the most effective remedies. A third deficiency, however, although resulting in somewhat similar symptoms, showed no such association. In this case the plants were stunted, the leaves turned yellow and their edges became brown, while there was a reduced production of tubers. These symptoms were traced to a deficiency of nitrogen, and the condition showed itself to be preventable by suitable dressings of nitrogenous fertilisers.

7. SUGAR BEET.

a. Virus Yellows. One of the most serious problems of the sugar beet crop in this country is the control of the disease known as "Yellows" or "Virus Yellows." The yellowing of the foliage of beet crops is so prevalent and widespread that it has been variously attributed to drought, excessive moisture, stony patches in the soil, mineral deficiencies, or simply normal ripening, according to the circumstances and the time of the year at which the condition is observed. It has now been demonstrated that by far the greatest amount of this yellowing is due to a virus infection which is known to be transmitted by one method only—the feeding on the crop of infected aphides, the most important of which are the peach potato aphis and the common blackfly or black bean aphis (Ref. 20). There does not appear to be any other means by which healthy plants can become infected, and the disease has never been shown to be carried by the seed; but it is most important to realise that mangolds, spinach, spinach beet and some weeds belonging to the same botanical family, such as goose foot or fat hen, are also susceptible and can therefore act as a source of infection.

Virus Yellows infects the root crop of sugar beet at different times of the year from season to season, and varies in severity from a comparatively mild attack to a serious epidemic. This variation in behaviour depends very largely on the behaviour of the

aphides, in particular whether they have been able to overwinter successfully, how quickly they can build up large populations in the early summer, and how far the weather conditions are suitable for their movement in the field. The peach potato aphis is capable of overwintering as an adult and reproducing itself during mild winters, but the blackfly overwinters only in the egg stage. As an adult, the peach potato aphis can live during the winter on brassica crops, or overwintering seed crops; in the egg stage the peach potato aphis survives on peach trees, and the blackfly on spindle trees. These " winter hosts " are not susceptible to the virus, and the disease is not carried in the eggs of the aphides, so that it is some time before spring-hatched flies are capable of starting infection in the root crop. In fact, usually it is too late for the peach potato aphis to infest the root crop in this way, and the virus is commonly introduced and spread by the blackfly. The peach potato aphis can infect the crop in early June if it has been able to overwinter successfully, but the infiltration is usually light and the disease does not spread extensively with the blackfly invasion in the latter part of July.

Aphides are only infective if they have fed on virus infected plants, and as the root crop starts off each year free from the disease, it is of the utmost importance to know the principal sources of infective plants. Undoubtedly one of the most serious sources of infection is the sugar beet seed crop, or in mangold areas, the mangold seed crop. Stecklings grown in areas where aphides are prevalent invariably become infected to a greater or less degree and the virus overwinters in the young plants. Seed crops, therefore, become a potent source of infection, as also do all other overwintering plants such as groundkeepers, tops, and horticultural and garden crops like spinach and spinach beet.

Agriculturally the most important immediate practical means of controlling Virus Yellows are to grow virus free stecklings and to remove all other possible sources of infection such as groundkeepers. If the seed crops could be kept free of the disease, one of the great dangers to the root crop in the seed-growing areas would be removed, while the yield of seed would be at the same time increased. The obvious method of growing virus-free stecklings is to remove the steckling beds to areas which are relatively free from aphides as is done in the growing of seed potatoes. There are certain practical difficulties to this procedure, but the method is being tried. Alternatively, steckling beds should be situated as far as possible away from root and seed crops of sugar beet and mangolds, the seed for stecklings should not be sown too early in areas where the root crop is infected in July, the steckling beds should have all diseased plants removed, and repeated spraying or fumigation to destroy aphides should be practised. All these methods cannot ensure absolute freedom of virus infection, but they can reduce the amount of disease in the seed crop following. Where steckling beds are badly infected, they should be ploughed out and plants obtained from healthier areas.

The risk of yellows infection of the root crop can be reduced by avoiding areas that are close to sugar beet and mangold seed crops. Cultural methods also affect the amount of disease in the root crop, but it is difficult to make general recommendations to cover all circumstances. For example, although the time of sowing has an important effect on the amount of Virus Yellows in the crop, the effect of time of sowing varies with the season because of the behaviour of the aphides. When peach potato aphis spreads the virus early, there is a more serious infection of early sown crops than of late sown ones, but where black fly is largely responsible, late sown crops suffer most because young plants are more attractive to the flies, as well as being usually more susceptible to infection and more easily crippled by the disease than are older ones. These considerations, however, do make it possible to state that, in general, early sowing is safer for most years, because by so doing the crop tends to be more lightly infected, and if infection does take place, the proportionate loss of the crop is lower.

There is a certain amount of evidence to show that the nutrition of the crop can affect the amount and severity of the attack. A well-manured crop, which grows rapidly in the early part of the season, is probably more resistant to aphis, and perhaps also to virus attack than is a poorly manured one, and experiments have shown that agricultural salt and nitrogenous fertilisers reduce the number of black fly on the crop. It is, however, true that virus infection causes a greater loss of yield on fully manured than unmanured crops, while the response to fertilisers is less on diseased than healthy crops. Nevertheless, a well-grown crop may still yield reasonably well in spite of being infected with Virus Yellows, whereas an infected badly grown crop may not be worth harvesting, When conditions have brought about an epidemic of the disease, all crops appear to become infected regardless of their condition, and the most important factor affecting the loss of yield is the earliness of infection. The magnitude of the losses due to heavy infection may be gauged by the fact that a crop in which all plants are infected in July may show a reduction of 50 per cent. of its potential sugar yield, but a similarly high degree of infection in mid-September may cause a reduction of only 15 to 20 per cent

Although cultural conditions of the root and seed crop are the only immediate and practical means of controlling Virus Yellows, there is hope that a more reliable method may eventually be found. The most effective means would obviously be to breed strains which are tolerant of the disease and thereby escape the serious results of infection. Tests which have already been made indicate that all strains in cultivation are of more or less equal susceptibility, although small differences have been found. It may be necessary to seek a higher degree of tolerance in some related plant, as for example in the wild sea beet which is now being studied for this purpose. If such tolerance is found in this material it will be necessary to embark on an extensive programme of sugar beet breeding in an endeavour to produce commercial strains combining Virus Yellows tolerance with desirable economic characters.

8. SWEDES.

a. Strain Trials. The National Institute of Agricultural Botany has published the results of four years' trials with fifty strains of swedes (Ref. 21). The strains have been classified into four groups—Green Skin, Dark Purple Skin, Light Purple Skin and Bronze Skin—which in certain cases correspond to types possessing particular agricultural characters. It is stated that, at the present time, the choice of a type appears to be more important as a general rule than the selection of a particular strain within that type, and although the grouping according to skin colour is convenient, the characters of greatest importance are frost resistance and dry matter. Colour and shape only have significance in special cases, as for example, where they affect the market value for human consumption, and of far more importance is the time of maturity which determines the optimum period of usage.

The Green Skin strains composed two distinct types—the Wilhelmsburger and the Wintergreen, both having small tops and showing resistance to frost, although Wilhelmsburger types were somewhat more hardy and less liable to splitting. Green Skin types were found to be high in dry matter content, as also were the Dark Skin Purple types, which were superior to the Light Purple Skin types in this character as well as in frost resistance. The Dark Purple Skin types—characterised by such strains as Bangholm, Champion, Acme and Stirling Castle—were more variable in most characters than were the Light Purple Skin types which were represented by Majestic, Magnificent, Eclipse and others.

The last group was the most variable, and although characterised as Bronze Skins, showed considerable differences in colour. Some of the strains, like Lord Derby, were as frost resistant as the Green Skins, but others, as for example, Jubilee, were very susceptible to frost damage. The Bronze Skins, like the Dark and Light Purple Skins, were for the most

part characterised by medium size tops and necks, although there were strains in each of these groups which showed either large tops or large necks, two characters which should be taken into consideration in choosing a strain of swedes.

G. D. H. BELL.

PLANT BREEDING INSTITUTE,
SCHOOL OF AGRICULTURE,
CAMBRIDGE.

References

1. The World Food Shortage *H.M.S.O. Cmd.* 6785: 1946.
2. Statistics and Documents Relating to The World Grain Position. *H.M.S.O. Cmd.* 6737: 1946.
3. Report of the Special Meeting on Urgent Food Problems. *Food and Agriculture Organisation of the United Nations. Washington D.C.* 1946.
4. Report of the Conference on the Post-War Loaf. *H.M.S.O. Cmd.* 6701: 1945.
5. Discussion: Sheep on Arable Land, *Jour. Farmers' Club* 1944. Pt. 1: 1-11.
6. JENKIN, T. J. The Foundations of Ley Farming. *Welsh Jour. Agric.* 1945: 18: 5-7.
7. The Establishment and Early Management of Sown Pastures. *Bull.* 34. *Imp. Bur. Pasture and Forage Crops, Aberystwyth,* 1945.
8. GRIFFITH, M. Establishment of Leys. *Welsh Jour. Agric.* 1945: 18: 9-12.
9. DAVIES, R. O. and MILTON, W. E. J. The Response of Grasses and Clovers to Treatment on Acidic Upland Soils V. *Emp. Jour. Exptl. Agric.* 1945: 13: 184-92.
10. Ley Farming in Sweden: A Field Day at Svalof. *Bull.* 33: 1945; *Imp. Bur. Pasture and Forage Crops, Aberystwyth.*
11. WILLIAMS, W., Varieties and strains of Red and White Clover—British and Foreign. *Univ. Coll. of Wales, Aberystwyth. Bull. Series H. No.* 16, 1945.
12. JONES, M. Grassland Improvement. *Scottish Journ. Agric.* 1945: 25: 133-39.
13. HATCHER, E. S. J. and PURVIS, O. N. On the Behaviour in the Field of Small Grain obtained by Premature Harvesting. *Jour. Agric. Sci.*, 1945: 35: 177-83.
14. M'DOUGAL, A. R. Grass Seeds Mixtures and the Effect on the Suppression of Weeds in Pastures. *Scottish Jour. Agric.* 1945: 25: 156-8.
15. M'INTOSH, T. P. Variations in Potato Varieties. *Scottish Jour. Agric.* 1945: 25: 125-32.
16. HUNTER, J. G. and M'GREGOR, A. J. An Investigation of Diseases resulting from Inadequate Nutrition of the Potato Plant. *Scottish Jour. Agric.* 1945: 25: 176-78.
17. SNELL, N. Reseeding in West Suffolk. *Jour. Min. Agric.* 1945: 52: 64-6.
18. MOORE, H. I. The Nurse Crop in Ley Establishment: An Analysis of Twelve Years' Records. *Jour. Min. Agric.* 1945: 52: 245-8.
19. ROBINSON, J. F. Variety Trials of Spring Wheat and Barley, 1939-44. *Pamphl. Univ. Coll. North Wales, Bangor,* 1946.
20. HULL, R. and WATSON, MARION A. Virus Yellows of Sugar Beet. *Jour. Min. Agric.* 1945: 52: 66-70.
21. Strains of Swedes. *Farmers' Leaflet No.* 10 (1946), *National Institute of Agricultural Botany.*

DISEASES OF ANIMALS

Bovine Mastitis.

The economic importance of bovine mastitis cannot be overestimated : and because of its prevalence much attention is given to the study of its control. During the past year many references appear in the literature which indicate the intensity of research and field work on the subject. In order to appreciate the difficulties confronting those engaged in devising methods of control it is necessary to point out that there are several types of bovine mastitis, that different kinds of micro-organisms are associated with the disease, that these micro-organisms do not all respond to the action of the agents used in the treatment of the diseased udder and that mastitis is easily spread from infected to healthy quarters.

The relationship of micro-organisms to mastitis is definitely accepted and although further work may show that we do not yet appreciate some of the basic or underlying considerations which lead to the development of the disease, it has been clearly shown that the removal of the associated micro-organisms from the diseased udder and the prevention of further infection by them go a long way to the control of mastitis in a dairy herd.

Most work has concerned *Streptococcus agalactiae*, the micro-organism associated with mastitis which gives rise to the greatest amount of the disease in this country : the work has been devoted to the cure of the infected quarters and the prevention of further infection.

Treatment of infected quarters. Attempts have been made to effect cures of infected quarters by the use of a variety of agents : they have been given by various routes, including directly into the quarter through the teat canal. In this country the methods used have been largely the administration of agents by mouth or their injection through the teat canal. Comparatively good results are obtained by dosing affected cows with the drug, sulphanilamide, in sufficiently large amounts at frequent intervals over several days. This treatment, while restoring the udder secretion to a normal condition, unfortunately does not sterilize the quarter : streptococci remain alive in the quarter and can give rise to further symptoms of mastitis. With the introduction of new agents, especially the antibiotic penicillin, attention has again been given to treatment through the teat canal.

An interesting Report has recently been published by the Committee on Animal Health, National Research Council, United States of America (Ref. 1) in which are given descriptions of the results of the uses of the various chemotherapeutic agents. The report says that "investigators agree that from 50 to 90 per cent. of udder infections with *Streptococcus agalactiae* are curable," and gives some particulars of the results of the use of five different agents in America. The following is a brief summary of the findings of the committee :—

1. The intramammary injection of neutral acriflavin (1 in 1,500) has proved to be irritant and may cause considerable damage to the udder tissue : following its injection the quarter has to be milked out within a short time. Little more than 50 per cent. of cures can be expected following three injections given from 7 to 14 days apart.

2. Silver oxide, 5 per cent. in mineral oil, injected in 10 c.c. amounts, is also irritant —it is said to be the most irritant of all the substances tried: it causes a reduction in milk yield which may not recover during the period of lactation. The percentage of cures varies from 35 to 80 per cent.

3. Sulphanilamide suspended in mineral oil and injected into the udder cures up to 90 per cent of infected quarters following four injections on successive days.

4. Tyrothricin and gramicidin (both of which have also been used in this country) are irritant: they are useful in dry cows.

5. Penicillin has been found extremely useful. The following quotation sums up the position—" On the basis of present knowledge, it appears that under average herd conditions the infusion of from 25,000 to 50,000 units of penicillin in water per injected quarter once a day for four consecutive days, is adequate to produce a cure in the majority of cases of *Strepotcoccus agalactiae* infections." The Report also says " Penicillin shows greater promise of effectiveness against *Staphylococcus aureus* of the udder than any of the other therapeutic agents now in use. However, the staphylococci are much more resistant to penicillin than the streptococci and therefore the dose levels effective against *Streptococcus agalactiae* are not so effective against *Staphylococcus aureus*."

The results of a comparison of some of these substances on a small scale in this country have been reported. Edwards and Brownlee (Ref. 2) worked with three substances— tyrothricin, sulphanilamide and penicillin: they treated 105 quarters in 41 cows, all infected with *Strepotcoccus agalactiae*, with sulphanilamide, made into an emulsion with lanette wax, arachis oil and water and found that, following one course of injections, *i.e.*, four daily injections, 78 were cured, while a further 12 were cured after two courses. Of the 15 quarters which failed to respond to this treatment 6 were cured when tyrothricin was used and 7 yielded to penicillin: two resisted all treatments. Tyrothricin was used on 18 quarters of 6 cows as a primary treatment; 14 were cured. Two of the failures responded when treated with sulphanilamide; two resisted all treatments. Twelve quarters of 6 cows were treated primarily with penicillin; 7 responded to two daily injections of 10,000 units and the remaining five were cured when sulphanilamide treatment was given. The results of this work indicate that the various substances used were of value and, that if one agent fails, better results may be obtained by further treatment in which one of the others is injected.

With the exception of sulphanilamide and penicillin, other agents have largely fallen into disuse. As penicillin has become more available greater use has been made of it in treating bovine mastitis: this is especially so in America and Canada, and following the release of supplies to the veterinary profession in this country, some results are now available.

The first reported use of penicillin came from America in 1944 when Kakavas published some results (Ref. 3). Since that time many publications have appeared: references to a few of them will indicate the present position. Murphy and Pfau (Ref. 4) carried out three experiments in which the sodium salt of penicillin was used. They found that single injections, even of quantities up to 200,000 units, were ineffective; but that repeated injections gave good results. Their best results followed the injection of 20,000 units at the usual milking intervals on five occasions; all of the 32 quarters so treated were cured. They found that " the effectiveness of the treatment did not appear to be dependant upon the lactation period, the week of lactation, the duration of the infection prior to treatment, the degree of induration at the time of treatment, or the degree of macroscopic alteration in the secretion present at the time of treatment." They found also that in these dosages there was no tissue damage, only slight transitory macroscopic changes in the milk and no adverse effect upon the volume of the milk yield. Horwood (Ref. 5) found that repeated

intravenous injections of penicillin were ineffective in freeing a quarter from infection ; but he showed that from 1,000 to 20,000 units injected by way of the teat canal gave good results in the chronic disease but that in some cows two or even three treatments were required. He also remarked on the relative non-irritating nature of penicillin and the very small reduction in milk yield during the treatment of cows even when in full lactation. Bryan, Cunkelman, Young and Visger (Ref. 6) found penicillin of much value : two cases of streptococcal mastitis are recorded which failed to respond to penicillin but which were treated by the injection of tyrothricin into the affected quarters. Hardenbrook and his colleagues (Ref. 7) found that 25,000 units of the sodium salt of penicillin proved to be relatively non-irritant : and only about 16 per cent. failed to respond to three treatments : the drop in milk yield during the week following treatment was 2.5 per cent. They found that equally good results were obtained regardless of the condition of the udder or the pathological changes which had developed within the udder : nor was there any correlation between the results of treatment and the number of lactations (1 to 5) or the stage of lactation (1 to 17 months).

Two references to work in Canada will show the position in that country. Schofield (Ref. 8) found that the success of penicillin treatment by the teat canal depended largely on whether the disease was present in an acute or a chronic state. He found that in acute mastitis, which is often due to infection with *Staphylococcus aureus* or *Corynebacterium pyogenes* only moderate clinical improvement is obtained unless the treatment is commenced immediately after the infection is established : with immediate treatment, however, the results may be highly satisfactory. In the more chronic type of mastitis, due to *Streptococcus agalactiae* infection penicillin treatment is satisfactory. Byrne, Pullin and Konsk (Ref. 9) report the results of penicillin treatment of 266 quarters : the infection varied, the majority being those of *Streptococcus agalactiae*. From one to six treatments were given at four-day intervals : the dose of penicillin varied from 10,000 to 100,000 units. They found that the best results were obtained in *Streptococcus agalactiae* infections when 40,000 units of penicillin were employed. In all, 204 of the 266 treated quarters recovered following from one to three treatments and 38 failed to show improvement after six treatments.

In this country little has, as yet, been reported on the use of penicillin in the treatment of mastitis. There has been published a short note which summarizes the work of a group of workers who participated in trials for the Agricultural Research Council. As this is an official statement it is reproduced unaltered (Ref. 10). " A high percentage of *Streptococcus agalactiae* infections can be sterilized with a minimum amount of udder disturbance by injection of penicillin by the teat canal.

			Infections sterilized.	
No. of Doses.	*Unitage*	*Interval*	*Cows.*	*Quarters.*
1.	100,000	—	31/62 (50%)	81/140 (57·9%)
2.	20,000	24 hrs.	52/71 (73·2%)	123/154 (79·9%)
4.	20,000	24 hrs.	47/65 (72·3%)	121/150 (80·7%)
4.	10,000	Successive Milkings	53/73 (72·6%)	125/150 (83·3%)

It is concluded from the figures that one injection is insufficient, even though the dosage be 100,000 units, but that there is no significant difference between the other three methods : injection of 20,000 units on two occasions at daily intervals, on practical lines is the method of choice."

Murphy (Ref. 11) has reported on his experiences and has come to the conclusion that penicillin treatment is the best and most economical in streptococcal cases and in mixed streptococcal and staphylococcal cases. He finds that for pure staphylococcal infections good results follow the use of staphylococcal toxoid treatment and that when failures occur

penicillin will probably be found of value in further treatment. Moon (Ref. 12) obtained clinical cures after two injections of 10,000 to 30,000 units of penicillin ; in dry cows in which it was not necessary to strip the udder he found that one injection was usually sufficient.

From all this evidence it is now apparent that to effect a bacteriological and clinical cure of bovine mastitis associated with infections of the udder with *Streptococcus agalactiae* penicillin is of much value : and further, if the penicillin treatment fails, good results may follow the use of other agents, *e.g.*, sulphanilamide injected into the affected quarters of the same cows.

In the control of bovine mastitis, however, the cure of the infected udders is only part of the story : prevention of spread of the infection must be rigorously undertaken. This subject was dealt with in last year's Journal. The results of recent work add to our knowledge of how infection spreads and how, in some measure, it may be curtailed. Thus, we have an interesting report from America by Spencer, McCarter and Beach (Ref. 13) in which the reservoirs of infection of *Streptococcus agalactiae* are discussed. They failed to find the micro-organism on the floor or in the bedding from beneath the infected cows. It was found, however, on the hands of milkers in a hand-milked herd, but could not be recovered from the hands of dairy attendants in machine-milked herds. We have evidence from work in this country of the persistence of these micro-organisms on the hands of milkers : this source of infection should not be overlooked.

It would appear, however, that one of the important factors in the development of mastitis is injury to the udder and teats. Further information on this subject is supplied from America and Canada. Thus Ferguson (Ref. 14) found that the intact skin of the opening of the teat is an effective barrier to the entrance of bacteria : when it is injured its external exposure to mastitis organisms readily favours infection. In 317 injured quarters dealt with, in which most of the injuries were due to teat treads, only 34 or 11 per cent. were free from infection and in most of them the teat opening was not involved. Compared with uninjured quarters it was found that 89 per cent. of infected quarters were associated with injuries while only 11 per cent. of 3,560 uninjured quarters showed mastitis. Stevenson (Ref. 15) working in Canada, submits further evidence on the association of mastitis with errors in the use of milking machines. He dealt with a herd of 30-40 milking cows in which the wastage from mastitis was heavy, despite hygienic precautions and treatment of affected quarters. He observed that the mucous membrane at the end of the teat opening was lightly everted. Although the milking machine appeared to be in order and the recommended pressure of 15 inches was recorded by the gauge in use, the actual pressure when a new gauge was fitted read 19 inches. When the pressure was adjusted a rapid improvement in the incidence of mastitis was found.

On the subject of the patency of the teat to udder infection, Murphy (Ref. 16) after carrying out some useful experiments, came to the conclusion that a " trend exists towards a greater incidence of infection in quarters the teats of which were judged to be patent than in those the teats of which were judged to be non-patent." He estimated patency by repeatedly applying sudden side-to-side pressure to the middle of the teat with the thumb and forefinger, the teat was always full of milk when the tests were made. It has sometimes been thought that the lining membrane of the teat canal, especially regarding its shape and form, may have a bearing on the occurrence of mastitis : thus in some cows the lining is in folds and there may be small pouches in it. Murphy (Ref. 17), however, has dispelled this idea, following his observations carried out both during the life of 205 cows and the post-mortem examination of many of them.

Johne's Disease in Cattle and Sheep.

In last year's Journal reference was made to the survival outside the body of the micro-organisms associated with Johne's disease in cattle. It was shown that they may

remain alive for long periods and support was given in the control of the disease to " the breaking up of manure on infected pasture land, the disposal of manure from standings to cultivated land and the drainage or fencing of ponds." The method of control generally practised has been the adoption of methods of husbandry whereby cattle, especially young cattle, have been excluded from exposure to natural infection. Without doubt this method has given, and continues to give, good results and the recommendation must still be the sheet anchor of the prevention of the disease. We have yet to learn the various factors which influence the occurrence of infection in some herds and not others and in some parts of the country to a greater extent than in others. Such points as the composition of the soil and the relationship of the nutrition of the animal, especially concerning available minerals in the pastures, have still to be studied.

The subject of immunity to Johne's disease has been studied in several countries and there are indications that the immunising of calves against the infection may have a definite place in controlling the disease, especially in heavily infected herds.

Following some observations in France on the protection of cattle against tuberculosis by the use of bacilli suspended in paraffin, Vallée and his co-workers (Ref. 18) reported good results from the use of a vaccine composed of Johne's bacilli suspended in paraffin to which some powdered pumice stone was added. They record the results of its use in 35,000 cattle without a single untoward incident : and they report further that it proved effective on 133 heavily infected farms and partially effective on 20 farms. The inoculation of the vaccine is followed by the appearance of a small inflammatory swelling at the point of inoculation : this swelling is gradually replaced by a small, non-painful, hard nodule which persists for a long time. The opinion of the above authors is that the injected animal remains protected only as long as the nodule persists and that if an animal is already infected before vaccination is carried out the nodule quickly disappears and the animals are no longer in an immune state. After some years' experience in France of this method of controlling Johne's disease, Lominet (Ref. 19) wrote " The method of Vallée and Rinjard is, in the opinion of veterinary surgeons and stockbreeders . . . the best method of protecting cattle. The safety and efficacy of the method are certain as has been proved by thousands of successful inoculations."

Work has also been done in America and in India with somewhat similar types of vaccine. More recently the study of Johne's disease with special reference to the question of immunity has been carried out by Doyle (Ref. 20) from the results of which a field trial of vaccination against the disease is now being undertaken in different parts of the country. Doyle first examined the question of the possible transmission of the disease by the injection of living Johne's bacilli under the skin. He used 5 calves and 11 goats for his preliminary observations. The dose he injected was large. Four of the calves were kept under observation for two years and eight months after which time they were subjected to post-mortem examination. No evidence of disease was found : nor did he find that any of the injected micro-organisms had survived at the site of injection although hard nodules had been produced. The dose given to goats was relatively larger than that injected into the calves : again, after as long as two years and seven months following the inoculation there was no evidence of disease in the injected goats, although there remained in the swellings at the site of inoculation micro-organisms which had been injected up to 15 months previously. From these results Doyle concludes that " the subcutaneous inoculation of living Johne's bacilli is a safe procedure."

Because of the reported successful results of the use of vaccine, especially in France, field trials are now being carried out in this country (Ref. 21). They will be continued for a number of years and are spread over the whole country. The work is being done only in heavily infected herds and vaccination is confined to calves, as soon as possible after birth

and not later than one month old. This is because it is believed that natural infection may take place early in life and therefore older animals may already be infected before vaccination: if such infected animals were vaccinated they might lead to confusion when the final results are being assessed. The present intention is to re-vaccinate at intervals of 12 to 18 months, although in the light of further experience the question of re-vaccination will probably have to be reconsidered. These field trials were initiated by the Agricultural Research Council: the Ministry of Agriculture is co-operating in the work.

Cattle infected with Johne's disease react positively when tested with mammalian tuberculin, avian tuberculin and with johnin It has always been recognised that such animals reacted positively to avian tuberculin and to johnin: in fact it was usually considered immaterial whether avian tuberculin or johnin was used for testing for the presence of Johne's disease. More recent work, however, especially with the newer types of tuberculin, show clearly that mammalian tuberculin also gives rise to a reaction in cattle infected with Johne's disease, although the reaction may not be so marked as is the case when the commonly used avian tuberculin or johnin is injected. This is not surprising from our present-day knowledge of the overlapping of the antigens which occurs in all the micro-organisms of the acid-fast group, to which belong the various types of tubercle bacilli and Johne's bacilli. The subject has been ably discussed by Green (Ref. 22). It is therefore almost impossible to state definitely from the results of tests made in cattle with the different types of tuberculin and with johnin whether the animals are affected with Johne's disease.

Johne's disease or an affection closely resembling Johne's disease in cattle is found in sheep. The disease has been recognised in this country for some years but more attention has been given to it within recent times. Johnston (Ref. 23) described a condition in sheep in 1933 in which he found enormous numbers of acid-fast bacilli in the mucous membrane of the small intestine. Dunkin and Balfour-Jones (Ref. 24) carried out some work on a group of sheep and succeeded in cultivating the responsible micro-organism from the infected animals: it was only following a very patient study that the bacilli were encouraged to grow under artificial conditions. Still more recent observations indicate that this disease is widely spread in the country (Ref. 25).

During the present year Michael (Ref. 26) has published some observations he made in North Wales. He finds that the disease is more widely spread among lowland and upland flocks than has hitherto been accepted: there was up to 5 per cent. of the sheep affected in some of the flocks with which he dealt. The affected sheep show a progressive loss of condition, with or without diarrhoea, with no response to anthelmintic treatment. There is often post-mortem-evidence of general thickening of the intestines and corrugation (as is found in cattle) but these lesions are not found in young sheep where the disease progresses rapidly. Michael found that a definitely positive reaction followed the use of johnin when injected into the caudal fold of the tail and that the sheep in the early clinical stage of the disease might show no reaction while the more advanced cases gave a definite response. He concludes, therefore, that to attempt to control the disease by removing reactors to the johnin test was impracticable. The disease appears to be subject to seasonal variation and its occurrence in a clinical form is probably related to the nutrition of the sheep and their infestation with worms. Cobalt deficiency of the diet, corrected by dosing the sheep with small amounts of cobalt sulphur would appear to enable them to overcome the infection to such an extent that symptoms do not occur and that the loss of condition is prevented.

Salmonella Infections in Fowls.

The Salmonella group of micro-organisms is important in that its members give rise to disease in most types of livestock and in human beings: they are the cause of much of the so-called " food poisoning " in man. There are many members of the group, some of them

being so closely related that it is only by the application of very delicate laboratory tests they can be differentiated. For many years two members of the group have caused much disease among poultry, *viz.*, those causing pullorum disease (B.W.D.) and fowl typhoid, respectively. Within the past few years there is much evidence that other members of the group infect poultry and may cause heavy losses especially among young chicks.

Pullorum disease, caused by *Salmonella pullorum*, is characterised by the fact that "carrier" adult fowls transmit the disease through infected eggs. The method of control is to find these "carriers" by the application of the blood or agglutination test and to remove them from the breeding flock. Much progress has been made in clearing breeding flocks in this country. While the disease causes heavy losses among chicks during the first few weeks after hatching, and infected adult fowls show no disturbance of health, occasionally the infection in adult fowls assumes an acute form with a resultant death rate. It may be said with every confidence that the methods now being operated are efficient in controlling pullorum disease and that with their extension, the disease can be eliminated from the country in time.

Fowl typhoid, caused by *Salmonella gallinarum*, differs from pullorum disease in that it affects adult fowls mostly and may cause considerable losses in an infected flock. While it appears most commonly in flocks where unhygienic conditions prevail and there is overcrowding and infrequent cleansing of the houses, outbreaks also occur periodically among fowls in well-run poultry plants. Wilson (Ref. 27) lays stress on the effects of overcrowding even temporarily and says "a serious outbreak followed a spell of wintry weather when, due to snow, birds were confined to the houses for several days on end, and in the only outbreak in turkeys I have seen the disease originated in a small pen in which "broody" turkey hens were isolated and which was overcrowded." No matter what the precipitating factors may be, however, the disease can only arise from the presence of *Salmonella gallinarum* : it exists in apparently healthy fowls which can be termed "carriers." Fortunately these "carriers" can usually be diagnosed by the same agglutination test as that used for the detection of "carriers" of pullorum disease : hence in the testing of breeding flocks by the agglutination test "carriers" of both diseases are found and thus the test fulfils a double purpose. It is of interest to record that although *Salmonella gallinarum* is found in the ovary of naturally infected fowls, there is no evidence of its recovery from eggs laid by "carriers" as is such a constant feature of pullorum disease.

Two other members of the group have been recognised as the cause of disease in chickens and ducklings, *viz.*, *Salmonella aertrycke* and *Salmonella enteritidis*. Many workers have recorded their findings of these micro-organisms especially in ducklings. Thus, Dalling and Warrack (Ref. 28) recorded losses from both infections and recovered the micro-organisms from duck eggs on several occasions : Hole (Ref. 29) described three outbreaks in ducklings : Garside and Gordon (Ref. 30) dealt with an extensive outbreak in ducklings and failed to find any evidence of transmission through the egg : Wilson (Ref. 31) recorded the results of his observations on losses in chicks, due to *Salmonella aertrycke*. Until 1943 these members of the group of Salmonella appeared to be the only ones concerned with disease in poultry : but in that year another member was found in infected chicks in this country—*Salmonella thompson*. This discovery was reported by Gordon and Buxton (Ref. 32) who state "during the years 1943 and 1944 *S. thompson*, not hitherto reported in poultry in this country, has been isolated on 44 occasions from 31 outbreaks in chicks and two outbreaks in ducklings." They described two extensive outbreaks. Wilson (Ref. 31) also refers to disease associated with *S. thompson*.

Since the recognition of disease due to infection with *S. thompson* was reported, the association of a further nine members of the salmonella group with disease in chicks has been recorded by Gordon and Buxton (Ref. 33).

The presence of many members of the group as casual agents of disease of chicks has been recognised for some years: Edwards and Bruner (Ref. 34) in 1939 reported on 20 different species and in 1943 (Ref. 35) listed 42 different types as having been recovered from poultry. Although we have this American evidence it is only within very recent times that the presence of these micro-organisms has been recognised in poultry in this country. It is impossible, without detailed laboratory examination, to diagnose infections due to these micro-organisms, for the symptoms and lesions in affected chicks are not characteristic of any special infection.

The question naturally arises as to the method of introduction of these infections into the poultry flocks of this country. We have very little evidence to support any theories which may be formed. The following is a quotation from Gordon and Buxton's publication (Ref. 33), "It may be that the appearance of these strains in poultry in this country during recent years is associated with war-time feeding, such as camp or canteen swill, household refuse, and the large-scale movements of populations to rural areas. That infection can occur in this manner has been amply demonstrated in the case of bacillary white diarrhoea, and it has been shown experimentally that the feeding of incubator refuse, uncooked swill and baker's waste can not only give rise to heavy mortality when fed to chicks, but may also produce a high percentage of carriers when fed to adult stock." It will also be remembered that these infections existed in poultry in America before they were demonstrated in this country.

There is also evidence that vermin (rats and mice) may barbour these infections: this is to be taken into account in considering the spread of infections.

These more recently introduced Salmonella infections cause losses among young birds: they do not seem to attack mature stock. Adult birds, however, harbour them, mainly in the intestine. The micro-organisms can be recovered from the intestine and the excreta. Several workers have demonstrated this point: for example Gibbons and Moore (Ref. 36) found that cultures fed to adult fowls were excreted for periods up to 38 days. They also recovered the organism from the shells of some of the eggs laid by the fowls so fed. They differ from *Salmonella pullorum* in that they do not appear to be passed through the egg and so set up infection in young chicks. In all probability young chicks are infected in the incubators either before or soon after hatching from infections which are collected on the outside of the shells of eggs laid by "carrier" fowls. It is important, therefore, in considering control measures to regard the incubator as the possible disseminator of infection. Fumigation of incubators is simply carried out and provided instructions are adhered to there is no danger attached to the developing chick embryos; nor are young chicks up to 48 hours old harmed by the process. A good description of a method, in which formalin and potassium permanganate are used, is given in the article by Wilson (Ref. 31).

Blood or agglutination testing has been studied by various workers with regard to its usefulness in diagnosing "carriers" of the more recently recognised Salmonella infections. The concensus of opinion seems to be that little value from a control point of view is to be derived from the application of this test; again, it will be noted that in this respect there is a great difference from the method of control of pullorum disease. The control of disease due to Salmonella micro-organisms other than those causing pullorum disease and fowl typhoid is summed up by Gordon and Buxton (Ref. 33) as follows:—"Routine blood testing of all poultry flocks for the detection of carrier adults does not appear to be a practical proposition, and even in flocks where the strain of salmonella involved has been established the agglutination test seems to be of limited value. At present, the control of salmonellosis depends on improved hygiene, particularly in hatcheries, on the eradication of vermin, on the use of vermin-proof foodstores, and on the adequate cooking of swill foods."

Poisoning in Livestock.

Some further information has appeared on poisoning of livestock by various agents. Our knowledge on this subject is still somewhat scanty : the attention of readers is therefore drawn to some of the reports which have appeared within recent times.

Lead Poisoning of Cattle. Fenstermacher and his colleagues (Ref. 37) add their experience to this subject. They find that the symptoms of lead poisoning vary considerably from animal to animal and that they are not always characteristic. For example, the blue line on the gums, which is held by some observers to be indicative of lead poisoning, is not often seen in cattle because it occurs only in chronic poisoning. There is usually a sudden onset of symptoms, consisting largely of prostration, staggering gait, boring into walls or fences, followed by inability to rise, and impaired vision. There is also grinding of the teeth, either constantly or intermittently. Death often occurs within a few hours of the appearance of symptoms. Post-mortem examination may show little of a striking character but when present the most prominent finding is an acute inflammation of the stomach and intestines. These authors believe that lead poisoning of cattle and especially of calves occurs more frequently than is commonly thought. It has to be pointed out, however, that, in the absence of good evidence of the consumption of lead, it is difficult to make a positive diagnosis without a chemical examination of organs. The consumption of lead by cattle is not always thought of when searching for a cause of illness because the source of the lead is not always obvious : cattle, however, seem to have a liking for lead and often find it in out-of-the-way places where it is not thought to be present

Copper Poisoning in Sheep. An account is given by Fincham (Ref. 38) of illness and deaths in sheep grazing in an orchard in which various insecticide sprays had been used, including copper sulphate and nicotine sulphate. After three to five days following the spraying the sheep were allowed into the orchards. Illness was observed in some of the sheep within a week or two and, in all, 12 out of 178 sheep in the orchards died. Some were found dead, others showed symptoms of inco-ordination of movement and weakness. It was interesting to note that 77 of the sheep were bought-in and were in better bodily condition than the others: none of them died or showed evidence of poisoning. Analysis of the livers of two of the sheep which died showed amounts of copper considerably in excess of those normally found in sheep and it is said that " in spite of the general unreliability of liver analysis to confirm copper poisoning the amounts found in these cases were certainly significant." It is thought that the better bodily condition of the 77 introduced sheep enabled their livers to detoxicate the poison better than those of the other, poorer, sheep. The weather was dry during and after the spraying and there was little growth of grass : it was felt that the absence of palatable grass to dilute the contaminated grass may explain the poisoning. Spraying had been carried out in much the same way in former years without any evidence of sheep being poisoned.

Salt (Sodium Chloride) Poisoning of Fowls. Salt poisoning of animals, especially fowls and pigs, has often been suspected by stock owners: there has been little accurate knowledge on the subject. Some careful work has been carried out by Blaxland (Ref. 39) in which he used fowls of different ages. He found that adult fowls could withstand large amounts of salt mixed in the food for some weeks without death occurring, although there was marked loss in condition : the main symptoms were excessive thirst and a profuse watery diarrhoea. A single feed of mash containing as much as 30 per cent. of salt caused only a low mortality (probably in those eating the largest quantity of the mash). It was found also that mashes containing large quantities of salt were so unpalatable that consumption was reduced and when fed over a period caused evidence of malnutrition. In baby chicks, however, the picture is quite different : there was, for example, 100 per cent. mortality within five days when even 0.9 per cent. salt in solution was given instead of drinking water and the feeding

of mash with 5 per cent. salt caused a heavy mortality within the first week. The post-mortem appearances of adult fowls following salt poisoning were quite indefinite and did not help in making a diagnosis : on the other hand in chicks there were definite and distinctive lesions, consisting of a generalised watery condition of the tissues and a congestion of the internal organs.

Field and Rees Evans (Ref. 40) also investigated the subject following losses on a poultry farm believed to be caused by the consumption of salt in the form of residual brine which was sprinkled over a small pen and also placed in heaps around the base of fruit trees in another pen. Several birds became ill soon after having access to the salt : they included turkeys and other varieties of poultry. The badly affected birds lost the use of their legs —those less severely affected could use their legs but only with considerable effort. In all cases there was a discharge of fluid from the beak and the affected birds continually opened and closed their beaks as if gasping for breath : in some birds the head and neck were drawn backwards. No evidence of thirst or diarrhoea was observed. By analysis it was shown that about 60 per cent. of pure sodium chloride had been consumed and this finding, together with the history, leaves little doubt that " the deaths experienced on this farm were due to the toxic effects of the quantities ingested."

Fluorine Poisoning in Sheep. Fluorine is known to be toxic for livestock : poisoning may follow the contamination of pastures and food stuffs with fluorine liberated from various substances during manufacturing processes. There is evidence to this effect in this country and from abroad. An interesting description of the occurrence in a chronic form in sheep is given by Boddie (Ref. 41). It occurred in sheep on three farms near an aluminium factory : all the home-reared adult sheep, but not the lambs, on the farm nearest the factory were affected, while on the farm furthest from the factory where the pastures were somewhat less heavily contaminated, the incidence of intoxication among the sheep was 48 per cent. The teeth were largely involved. The incisors showed mottling of the enamel and some were deformed and brittle and in some sheep, interfered with grazing. The molar teeth showed poor wearing quality with the result that long pointed projections occurred, causing ulcerations on the gums. The milk teeth were not affected as they are shed before the lambs start grazing. There was also suppuration at the roots of the teeth and an inflammation of parts of the jaw. These occurrences all interfered with grazing and chewing : and resulted in a poor bodily condition of the ewes because of which lambs were born weakly and reared badly due to the scarcity of milk produced by the affected ewes.

Castor Bean Poisoning in Horses. The toxicity of the castor bean is well recognised and from time to time reports of its occurrence are recorded. Such poisoning is usually accidental, being due to the accidental contamination of feeding stuffs with small quantities of castor beans. An interesting record of castor bean poisoning in horses was recently published by McCunn (Ref. 42), the source of the beans being the bursting of bags containing them in the hold of a grain boat which contained loose grain. The grain was extracted from the boat by a suction pump and the spilt beans were accidentally included. As the grain was bagged direct from the suction pump and tipped straight into the mill and ground, the castor beans were not observed. The important symptoms shown by the affected horses were profuse sweating and blowing, a rocky gait, some signs of abdominal pain and diarrhoea : sometimes the diarrhoea was delayed for some days after consumption of the contaminated food. The points that struck the observer most were the unpalatability of castor beans for horses, because none of them ate more than a few mouthfuls of the contaminated food : the small amount of the bean which can give rise to toxic effects : and the delayed action in many of the cases. In all 7 of the 48 horses died : the others gradually recovered and were at work again in 14 to 21 days after the appearance of the illness.

Brucellosis (*Contagious Abortion*).

The control of brucellosis in this and other countries is now largely centred around immunisation for which live, attenuated cultures of the causal micro-organism, *Brucella abortus*, are used. The strain most commonly used is the American strain 19: it is being widely used in this country. Up till very recent times most of the knowledge we had on the immunising value of this strain was derived from the results of experiments in America and a few other countries. We have now definite information from work carried out in this country, for Edwards and his colleagues have now published the records of the experiments planned by the Brucellosis Committee of the Agricultural Research Council (Ref. 43). Fifty maiden heifers were used in the experiment: they were all consistently non-reactors to the agglutination test before the beginning of the experiment. They were divided into five groups of 10, and each group was housed in separated premises under strict conditions of isolation. Each heifer in two of the groups received an injection of strain 19 vaccine--two groups were unvaccinated and were used as controls to the effect of the vaccine--the fifth group received neither vaccine nor the infecting dose of *Br. abortus* and were kept as a check on the methods of isolation. All fifty animals were mated: all but one of the vaccinated heifers proved in-calf, while three of those which had not received vaccine proved to be barren. When the majority of the heifers were in about the fifth month of pregnancy the twenty vaccinated and the twenty control, unvaccinated animals were exposed to infection with *Br. abortus*: ten vaccinated and ten control animals were given a large dose of the infecting culture while the other ten in each group received a small dose of about one-tenth of the amount given to the others. It will be remembered that the fifth group was neither vaccinated nor infected: this group behaved normally in that all the animals were proved to be free from infection with brucellosis at the end of the experiment: hence it can be concluded that the methods of isolation were sufficient to prevent the spread of infection from group to group.

Tests carried out during the experiment comprised examination of blood samples by agglutination, examination of milk and bacteriological examination of foetal membranes and tissues from aborted or dead calves. Agglutination tests showed that reactions followed the injection of the vaccine and that the titres (extent of the agglutinations) gradually fell until the animals were exposed to infection when they rose again but to a less degree. In the non-vaccinated animals no reactions were found until infection was carried out when the titres attained a higher level than in the vaccinated groups. In the heifers which were not rendered immune by the injection of the vaccine, the agglutination titres behaved much as did those in the control animals.

The following table shows the results of the experiment :—

		Number of animals which developed infection	Number of living calves	Number of milk samples with *Br. abortus* infection during 10 weeks after calving.
Small Infective Dose	Vaccinated	1 out of 9	9 out of 9	0 out of 90
	Controls	9 ,, ,, 9	3 ,, ,, 9	70 ,, ,, 100
Large Infective Dose	Vaccinated	2 ,, ,, 10	8 ,, ,, 9	9 ,, ,, 100
	Controls	10 ,, ,, 10	1 ,, ,, 10	55 ,, ,, 100

It will be seen from the table that highly satisfactory results were obtained. The explanation of the samples of infected milk among the vaccinated animals in the "large infective dose group" is that 8 positive samples were obtained in the ten-week period from

one cow and one sample from another; both cows failed to resist the infection (two cows out of the 10 became infected). In all cases the micro-organisms recovered corresponded in all respects to those used in the infecting doses: there was no evidence of the recovery of the vaccinating strain (strain 19). The conclusions are as follow: "As a result of this experiment it may be concluded that a vaccine prepared from *Br. abortus*, Strain 19 confers a substantial degree of immunity in cattle against a virulent infection applied 35 weeks after vaccination. No evidence of the establishment of a persistent infection from the vaccine strain was obtained."

These findings take us a considerable distance in our first-hand knowledge of immunising cattle against brucellosis. We have yet to ascertain how long the immunity remains effective: until we have this information we shall not be in a position to make any authoritative statement on the question of the necessity for revaccination or, if it is necessary, on the interval between vaccinations.

Supporting the above results come some practical observations from New Zealand. Observations following field trials (Ref. 44) show that in 1943, 18,332 heifer calves in 1,160 heavily infected herds were vaccinated with vaccine prepared from *Br. abortus* strain 19. In that year the incidence of abortion in 11,268 of two-year old unvaccinated, mated heifers in these herds was 22.1 per cent. In 1944 the abortion figure from 10,725 of these vaccinated calves (now mated heifers) was 3.0 per cent. Actually 2 per cent. of these abortions were due to *Br. abortus* infection. The average abortion rate for heifers in New Zealand is 12 per cent. Figures from the same source are available for 465 heifers in infected herds vaccinated in 1942 and bred in 1943 and 1944. In 1943 4.7 per cent. aborted and in 1944 the abortion figure from all causes was 1.4 per cent.

It is of much interest to farmers in this country to observe that a plan to vaccinate calves has been approved by the South Australian Dairymen's Association. It will be under the direction of the Chief Inspector of the Livestock Division of the Department of Agriculture and officers of that Division will carry out the vaccinations (Ref. 45).

An interesting observation has been recorded by McDiarmid (Ref. 46) on the transference of agglutinations for *Br. abortus* from the cow to the calf. He has shown that agglutinins cannot be demonstrated in the blood of the calf until it has had colostrum which contains these immune bodies. The agglutinins appear in the calf's blood within one to three hours of the ingestion of such colostrum and reach their maximum within 24 hours. The rate at which they disappear depends largely on the extent of the agglutinins in the cow's colostrum: they may persist in the calf for as long as 18 weeks. No evidence was found to show that the presence of *Br. abortus* in the milk consumed by calves had any effect upon the agglutinins in their blood: the presence and persistence of agglutinins in the blood of calves depends largely upon the extent to which they are present in the colostrum and milk fed to them. It is of importance to note that although agglutinins develop in the blood of calves fed on such colostrum and milk they disappear long before the animals are of breeding age.

Digestive Disorders of Cattle.

Attention is being directed to the occurrence of forms of digestive disturbances which occur in cattle from time to time: the subject is a complex one but one aspect to which more consideration is now being given is the occurrence of "bloat" or "hoven," especially in cattle at pasture. Tympany of the rumen is the term usually applied to this condition: it may occur in a chronic form when it is often associated with some obstruction at either the entrance to or the exit from that organ. Recently Ascott (Ref. 47) described some of the causes he had found; all were verified by post-mortem examinations. They were tuberculosis of the posterior mediastinal glands, tuberculosis of the oesophagus, carcinoma

of the rumen, papilloma of the rumen and the presence of an open safety-pin in the reticulum. All these conditions and occurrences interfered with rumination and allowed the accumulation of the various gases in the rumen with resulting tympany.

Gould (Ref. 48) draws attention to the necessity for the careful control of stock in the grazing of leys or reseeded pastures. He finds that without reasonable precautions digestive disorders may occur and not infrequently affected animals die. The chief disorders he finds are tympanitis of the rumen, *i.e.*, " hoven " : impaction of the rumen, with a varying degree of tympanitis, for the alleviation of which it may be necessary to perform the major operation of rumenotomy (removal of the contents of the rumen) : " allergic indigestion " for which some protein or protein derivative of the herbage may be responsible and which is associated with tympanitis due " presumably to the contraction of smooth muscle fibre closing the rumen " : urticaria (nettlerash or " blain ") : entero-toxaemia associated with foetid diarrhoea and recumbency which occurs more often in cows and heifers in the later stages of pregnancy and in freshly calved cows. He finds these conditions mostly on first year leys and on reseeded pastures but they also occur on established second and third year leys. His method of preventing these troubles is by a system of management whereby the animals are " rationed " *i.e.*, they are turned out to the leys for short periods only and are then removed to a bare pasture or yard. The cattle are allowed access to the pasture for one to 1¼ hours on each of the first few days and then slightly longer. He has also found that the feeding of hay or straw prior to turning out the cattle may be of value and subsequently to feed straw at pasture. This method proved successful in the autumn : he has not tried it on the spring grazing of leys. From the behaviour of the stock he came to the conclusion that the above types of pastures are less palatable than older swards and are " deficient in roughage, some unidentified nutritional factor(s) or both."

Work in America by Cole and Kleiber (Ref. 49) consisted in the estimation of the pressure in the rumen in cattle suffering from " bloat." They were able to show that when the pressure reached 10 to 17.5 m.m. of mercury most animals stopped eating : those which continued to eat were most likely to " bloat " seriously and in severe cases the pressure rose to as much as 63.5 m.m. of mercury. Animals in which such a pressure was maintained became progressively more distressed and, in some, death resulted. It was also observed that when cows were given hay the night before being turned into pasture " bloat " was prevented provided they ate at least 17.7 lb. per head : some animals consumed more pasture after being fed hay than did those which did not receive hay.

A further theory of the causation of " hoven " is given by Kerr and Lamont (Ref. 50). From some other work they had done, and in which tympany of the rumen in an acute form occurred, they formed the opinion that an allergic shock occurs which causes a spasm of the unstriped muscle of the oesophagal opening into the rumen : this prevents the gas in the rumen from being got rid of in the usual way, with the result that it accumulates in the rumen and causes acute tympany.

As our knowledge on the physiology and the biochemical processes concerned with digestion in ruminants becomes better understood, our knowledge of the causation of the above conditions will increase and preventive methods will follow. In the meantime, the attention of readers is drawn to the findings of the above workers whose practical experiences may be of value in controlling these affections which are so commonly found in some districts.

T. DALLING.

VETERINARY LABORATORY,
NEW HAW,
WEYBRIDGE, SURREY.

References

1. Committee on Animal Health, National Research Council. "The intramammary therapy of bovine mastitis." *J. Amer. Vet. Med. Ass.* 1946, **CVIII.** 126-135.

2. EDWARDS, S. J. and BROWNLEE, A. Therapeutic treatment of bovine mastitis. *Vet. Rec.* 1946, **58,** 335-343.

3. KAKAVAS, J. C. Penicillin in the treatment of bovine mastitis. *N. Amer. Vet* 1944, **25,** 408-412.

4. MURPHY, J. M. and PFAU, K. O. The value of local injections of penicillin sodium in the treatment of *Streptococcus agalactiae* infection and mastitis in cows. *Cornell Vet.* 1945, **XXXV.** 88-103.

5. BRYAN, C. S., HUFFMAN, C. F. and HORWOOD, R. E. A preliminary report on penicillin in the treatment of chronic streptococcic mastitis. *Vet. Med.* 1945, **XL.** 87-89.

6. BRYAN, C. S., CUNKELMAN, J. W., YOUNG, F. W. and VISGER, E. E. The treatment of acute infectious bovine mastitis with penicillin. *Vet. Med.* 1946, XLI, 92-98.

7. HARDENBROOK, H. J., ALBERTS, J. O. and BRYAN, C. S. Studies in bovine mastitis. III. Penicillin therapy in streptococcic mastitis. *J. Amer. Vet. Med. Ass.*, 1946, **CVIII.** 140-142.

8. SCHOFIELD, F. W. Penicillin in the treatment of bovine mastitis. *Can. Jl. Comp. Med.* 1946, **X.** 63-70.

9. BYRNE, J. L., PULLIN, J. W. and KONSK, H. Studies in infectious mastitis. I. Penicillin as a therapeutic agent. *Can. Jl. Comp. Med.* 1946, **X.** 16-23.

10. ——— ——— Penicillin in bovine mastitis. *Vet. Rec.* 1946, **58,** 138.

11. MURPHY, R. The treatment of mastitis. *Vet. Rec.* 1946, **58,** 277-279.

12. MOON, G. J. H. Penicillin in the treatment of mastitis. *Vet. Rec.* 1946, **58,** 326.

13. SPENCER, G. R., MCCARTER, JANET and BEACH, B. A. Reservoirs of infection of *Streptococcus agalactiae*. *Am. Jl. Vet. Rec.* 1946, **VII.** 32-36.

14. FERGUSON, JEAN. A bacteriological study of the infections which follow injury to the bovine udder. *Am. Jl. Vet. Rec.* 1944, **V.** 87-92.

15. STEVENSON, W. G. Injury as a cause of mastitis. *Can. Jl. Comp. Med.* 1946, **X.** 115-116.

16. MURPHY, J. M. The relation of teat patency to udder infection. *Cornell Vet.* 1944, **XXXIV.** 64-68.

17. MURPHY, J. M. The relationship of the teat mucous membrane topography to age, breed and incidence of udder infection in cows. *Cornell Vet.* 1945. **XXXV.** 41-47.

18. VALLEE, H., RINJARD, P. and VALLEE, M. Sur la prémunition de l'entérite paratuberculeuse des bovidés. *Rev. Gen. Med. Vet.* 1934. **43,** 777-779.

19. LOMINET, G. L'entérite paratuberculeuse dans le département de la Manche. *Rev. Gen. Med. Vet.* 1936, **45,** 278-281.

20. DOYLE, T. M. Vaccination against Johne's disease. *Vet. Rec.* 1945, **57,** 385-387.

21. ——— ——— Vaccination against Johne's disease. *Vet. Rec.* 1946, **58,** 241.

22. GREEN, H. H. The limitations and uses of the comparative method in medicine. *Proc. Roy. Soc. Med.* 1944, **XXXVII.** 441-443.

23. JOHNSTON, D. Johne's disease in sheep. *Vet. Rec.* 1933, **XIII.** 1388.

24. DUNKIN, G. W. and BALFOUR-JONES, S. E. B., Preliminary investigation of a disease of sheep possessing certain characteristics simulating Johne's disease. *J. Comp., Path. & Therap.* 1935, **48,** 236-240.

25. TAYLOR, A. W. Ovine paratuberculosis (Johne's disease of sheep). *J. Comp. Path. & Therap.* 1945, **55,** 41-44.

26. MICHAEL, D. T. Some clinical observations on Johne's disease of sheep. *Vet. Rec.* 1946, **58,** 297-298.

27. WILSON, J. E. Fowl Typhoid, certain aspects of the experimentally produced disease. *Vet. Rec.* 1946, **58,** 269-271.

28. DALLING, T. and WARRACK, G. K. Ducks and Salmonella infection. *J. Path. Bact.* 1932, **35,** 655.

29. HOLE, N. Salmonella infections in ducklings. *J. Comp. Path & Therap.*, 1932, **45,** 161-167.

30. GARSIDE, J. S. and GORDON, R. F. Salmonella infection of ducks and ducklings. *J. Comp. Path. & Therap.* 1940. **53,** 80-89.

31. WILSON, T. E. Infected egg shells as a means of spread of salmonellosis in chicks and ducklings. *Vet. Rec.* 1945, **57,** 411-413.

32. GORDON, R. F. and BUXTON, A. The isolation of *Salmonella thompson* from outbreaks of disease in chicks. *Jl. Hyg.* 1945, **44,** 179-183.

33. GORDON, R. F. and BUXTON, A. A survey of salmonellosis in Great Britain. *Vet. J.* 1946, **102,** 187-206.

34. EDWARDS, P. R. and BRUNER, D. W. The antigenic analysis of Salmonella species derived from domestic animals. *Rep. Proc. 3rd Int. Cong. Microbiol*, 1939, 629-630.

35. EDWARDS, P. R. and BRUNER, D. W. The occurrence and distribution of Salmonella types in the United States. *J. Inf. Dis.* 1943, **72,** 58-67.

36. GIBBONS, N. E. and MOORE, R. L. A note on artificially infected fowls as carriers of salmonella. *Poult. Sci.*, 1946, **XXV.** 115-118.

37. FENSTERMACHER, R., POMEROY, B. S., ROEPKE, M. H. and BOYD, W. L. Lead poisoning in cattle. *J. Amer. Vet. Med. Ass.*, 1946, **CVIII.** 1-4.

38. FINCHAM, I. H. Copper poisoning in sheep. *Vet. Rec.* 1945, **57,** 581.

39. BLAXLAND, J. D. The toxicity of Sodium Chloride for fowls. *Vet. J.* 1946, **102,** 157-173.

40. FIELD, H. I. and REES EVANS, E. T. Acute salt poisoning in poultry. *Vet. Rec.* 1946, **58,** 253-254.

41. BODDIE, G. F. Chronic fluorine intoxication in sheep and its effect upon the teeth. *Proc. Nutrit. Soc.*, 1945, **3,** 94-97.

42. McCUNN, J. Castor-bean poisoning in horses. *Vet. J.* 1945, **101,** 136-138.

43. EDWARDS, S. J., McDIARMID, A., DE ROPP, R. S. and McLEOD, D. H. Immunity in cattle vaccinated with *Brucella abortus* strain 19 and a note comparing this strain with 45/20. *Vet. Rec.* 1946, **58,** 141-146.

44. ——————The role of vaccination in the control of brucellosis (contagious abortion) in dairy cattle. *J. Dept. Agric. S. Australia*, 1946, **XLIX.** 336-337.

45. ——————Vaccination of calves against brucellosis (contagious abortion) *Ibid.* 335.

46. McDIARMID, A. The transference of agglutinins for *Brucella abortus* from cow to calf and their persistence in the calf's blood. *Vet. Rec.* 1946, **58,** 1[illegible]3-149.

47. ASCOTT, E. W. Chronic tympany of the rumen. *Vet. Rec.* 1946, **58,** 39.

48. GOULD, G. N. A preliminary note on digestive disorders of cattle associated with leys and re-seeded pastures. *Vet. Rec.* 1945, **57,** 365.

49. COLE, G. H. and KLEIBER, M. Bloat in cows on alfalfa pasture. *Amer. J Vet. Res.* 1945, **6,** 188-193.

50. KERR, W. R. and LAMONT, H. G. Hoven—an expression of allergy ? *Vet. Rec.* 1946, **58,** 6-7.

FARM ECONOMICS

I. WORLD AGRICULTURE.

NEVER before in living memory has the uncertainty of Britain's food supplies, derived as such a large part of them is from other countries, been brought home so clearly to our people. It was a commonplace during the long years of peace and plenty before the first world war, as also in the period between the two wars, that we were dependent on imports for most of our cereals, and for nearly half of the animal products which we needed, but there was never any question in the minds of most people that the necessary supplies would reach us. Recently, another great war has ended and the country is at peace again, but it has left an economic dislocation of production and distribution so serious that the whole world is facing a food shortage. The causes in general are well known, but the Minister of Food has taken the occasion " to set out the facts of the present crisis in the world's food supplies, to show how the crisis developed, and to trace the steps taken by the Government in the face of it " in a White Paper presented to Parliament last April. As regards bread grains, it is pointed out that notwithstanding a reduction in the aggregate acreages in the four great exporting countries, the U.S.A., Canada, Argentina, and Australia, of more than one-fifth during the war years, a succession of good crops in North America resulted in a rapid increase in stocks of wheat up to the end of 1943. From that time the position deteriorated, mainly owing to the greatly increased use of wheat for animal feeding in the United States, and for the production of alcohol for the manufacture of synthetic rubber. Even so, the exportable surplus for 1945/46 was estimated to be about twice the pre-war average.

Unfortunately even these supplies fall seriously short of import requirements. The European needs at nearly 16 million tons are four times higher than pre-war requirements, while crop failures in other parts of the world, both of wheat and of rice, have added another 16 million tons to total world import needs. On estimates for the 1945/6 crop, the world deficit of wheat is about 8 million tons.

As to livestock and livestock products, production in Britain, and indeed in all the European countries, has suffered a drastic decline through the loss of overseas supplies of fodder and the diversion of home produced cereals to direct human consumption. Production was stimulated, however, in North America to meet the heavy demands of the Allied Services, and there was some expansion in South America, but shortage of shipping prevented any increase in the Southern Dominions. Supplies of meat in the immediate future depend mainly on the size of this year's grain harvest.

In the first White Paper, and in another one embodying a later review, the whole position has been set out, together with full statistics of production and estimates of demand. A third Paper provides the student with statistics relating to the world grain position for wheat, barley and rice, both acreage and production, for the years 1938/1945. (Refs. 1, 2, 3).

Much has been expected of the Food and Agriculture Conference of the United Nations, which was held at Hot Springs, Virginia, U.S.A. in 1943, to consider how best to secure freedom from want in relation to food. The first session of the Food and Agriculture Organisation set up by it was held in Quebec in October and November, 1945, under the chairmanship of the Director-General, Sir John Boyd Orr. Considerable progress was made then and since in formulating a scheme, the basis of which is to treat the feeding of the people of the world as one problem which can be solved only by united action for planning the production and distribution of food. Documents relating to the first session have been published (Ref. 4).

Increasing attention has been given in recent years to the planning of land-use. The matter has been forced upon the notice of the soil scientists and administrators by the growing evidence of erosion in various parts of the world, not only following the active misuse of land for cultivation and cropping but also, indirectly, following the denudation of forest cover and excessive stocking of natural pastures by native populations. In this country a favourable climate and a farming system suited to our conditions evolving through a thousand years and more, remove any question of erosion and might seem to have settled, by now, the question of *optimum* land use. We have only to consider, however, the drastic changes in the ratio of grass land to arable land made necessary by recent national needs, to realise that fundamental modifications of present use are possible even in a country which has enjoyed political stability for so long. In some of the newer countries of the world, particularly, with very little agricultural tradition, and in some of the older countries affected by changing economic and social conditions, the planning of land-use is of first-class importance. A contribution to its consideration, based on the grouping and classification of lands according to their suitability for producing plants of economic importance, has been issued by the Imperial Bureau of Soil Science, in which are described the natural indications of land quality and the methods of land classification and of estimations of soil productivity adopted in various countries. (Ref. 5).

II. FARM MANAGEMENT.

(*a*) *The Farm Management Survey.*

Reference was made last year in this annual summary to a general Farm Management Survey which has been in progress throughout the country during the war years and before, covering upwards of 2,000 farms. The work has been carried out locally by the provincial Advisory Economists, and the financial results on farms grouped according to types of farming and locality have been prepared in summary form by the Agricultural Economics Research Institute, at Oxford. At the same time, the Advisory Economists themselves have made comparative studies of the results of farming in the different districts of their respective provinces. The general reports serve to indicate the capitalisation, profitability and other general features of the farming industry of this country, while the more detailed local studies are of particular interest and value to farmers within these areas. Most of these reports have been treated as confidential during the war years, but this ban on general publication is no longer imposed, and they can now be consulted in mimeographed form on application to the various centres issuing them. (Refs. 6 to 18). This survey must not be confused with the National Farm Survey conducted by the War Agricultural Committees on behalf of the Ministry of Agriculture and Fisheries, the results of which are shortly to be published.

(*b*) *Costs of Production.*

(*i*) *Crops.* From the newly re-constituted Wye College comes a valuable report on the costs of arable crops grown on the College farms during the years 1939-44. It is the third of a series which give the detailed analysis of the costs of production and financial results for the

past eighteen years. Notes are given on variations in the weather (rainfall fluctuated from 18 in. to 32 in.), in the soils and in the cropping policy, as aids to the interpretation of results in particular years. It is difficult to know how to assess these, however, as guides to future management, owing to the high rate of profit on almost everything grown during the war years. What can one argue, for example, from operations which resulted in a net profit of nearly £21 an acre from the barley crop of 1942-43 ? And even though such a figure makes a profit of something less than £5 an acre for the oat crops of the same years look negligible, what farmer would not have been well content with it in the years between the two wars ? The utmost care is needed when trying to interpret the costs and returns of farming under emergency conditions. This, however, does not detract from the value of this report. (Ref. 19).

Two reports on the cost of the oat crop in 1945 are available, both of them local studies, the one made in Northumberland and Durham and the other on farms in the North of Scotland. They contain figures for the costs of production and are available to farmers in the regions to which they relate. (Refs. 20 and 21).

Another crop of special importance in Scotland is the potato, though more perhaps in the south than in the north. Figures are available for the cost of growing potatoes in North-east Scotland, where very little ware was produced, although a few farmers had developed the production of seed potatoes. War-time necessities increased the attention given to the commercial production of ware, and led to an investigation of the methods and costs of production by the North of Scotland College of Agriculture. Costs are very much as might be expected, and when related to yields, do not seem to indicate a great future for market production so far north. (Ref. 22).

Two advisory centres, the University of Leeds and the Midland Agricultural College, made studies of the costs and returns of the sugar beet crop of 1945. It is interesting to note the similarity of the results from the two places, the average of the Yorkshire farms showing a net cost of £2 16s. 8d. per ton, while that of the Midland farms was £2 8s. 6d. (Refs. 23 and 24).

The study of the flax crop by the East of Scotland College at Edinburgh, to which reference was made in this review last year, has been continued, and figures from a total area of 836 acres on 71 farms are now available. Flax seems to be grown in Scotland as the first crop after grass, whether old grass ploughed up or rotational grass ; otherwise it replaces part of the root-break after cereals. All of it was grown under contract, there being few changes in that for the 1944 crop, though prices were somewhat higher for the top three grades and lower for the bottom grades. This incentive to efficiency by price discrimination is one to be encouraged wherever production of farm produce on contract is organised. Costs per acre show little variation, whatever the place of the crop in the rotation, but yields, and consequently profits, were notably higher where the crops followed rotation grasses or roots. (Ref. 25).

Costs of the production of hay come from places so far apart as Durham and Devon. The quantity of hay coming on the market is probably very small, and what the farmer needs is more information, if it were possible to get it, relating his costs of production to the feeding value of his crop. This, of course, would involve an intimate examination of other factors besides costs, the compensation of the herbage, the stage of growth at which the crop is cut, weather conditions during curing, and so on, all of which have an important influence on nutritive values. Hay, unfortunately, is not just hay. (Refs. 26 and 27).

An advisory report for farmers on the costs of growing farm crops in 1945 in the district served by the West of Scotland Agricultural College has recently been issued. It represents the first results of work on crop costing presented both in summary form and in detail, to show money costs and man, horse and tractor-hours employed per acre in the work. A common

difficulty confronting farm economists is how to make the results of their investigations of direct service to individual farmers. In this case, every farmer participating in the investigation by furnishing records is given a comparative statement showing how his costs compare at each stage in the process of production with those of the others. If his costs should be lowest, he can congratulate himself, but where others are doing better, he is challenged to reconsider his own methods. This use of research for advisory purposes is not new, but it is not so general as it might be. (Ref. 28)

(*ii*) *Livestock.* The cattle rearing industry and meat production in this country have experienced chequered fortunes for some time past. At one time Britain's most important livestock industry, it was severely assailed by the increasing quantities and improved quality of chilled and frozen meat from overseas, and more recently it has lost pride of place within our own country to the ever-growing dairying industry. In some parts of Britain it is still of first class importance, and farm economists have devoted some attention to it. Under the somewhat ambiguous title of " Uses of Bulls in Wales, 1935-36 to 1944-45," the Department of Agricultural Economics at Aberystwyth has made an intensive study of the types of sires in use in Wales. The average service life of a bull is only about two and a half years ; the county of Carmarthen produces nearly 25 per cent. of the total number of bulls in Wales ; and the Shorthorn still accounts for half of the total number. There has been a notable increase, however, in the last ten years, of British Friesians. In 1936, Shorthorns accounted for nearly-two thirds of all the bulls licensed, and the Friesians three per cent., while in 1945 the former had dropped to 49 per cent. and the latter had risen to 28 per cent. In the same period, the use of Herefords had declined from about 20 per cent. to less than half this figure, but Welsh Blacks, though fluctuating from year to year, are maintaining their position fairly well. The general inference is that more attention is being paid to dairying types, owing to the higher profitableness of milk production, and to the necessity of intensifying the production from small farms, which could only be achieved by more concentration on milk. (Ref. 29).

The cost of cattle rearing and feeding has been studied at one or two centres. In Devon, where dairying has been steadily gaining ground, and markedly so during the war years, fewer store cattle are being raised for beef production. The bulk of the cows calve in the spring, so that the calves are mainly reared in the summer, and only on comparatively few farms are they kept for feeding. In North Devon, more than 80 per cent. of the home-reared stock are sold as stores. Details of the methods pursued in rearing stores, with costs at each stage of development, have been published in an interesting report emanating from the Department of Economics of Bristol University at Newton Abbot, from which it appears that Devon farmers must have reasons for producing store cattle other than getting direct profits in the process. (Ref. 30).

The economics of beef production when the store stage is past is the subject of reports from the Midland Agricultural College and the Harper Adams Agricultural College. The former particularly is a fully documented study, but from neither of them will the feeder of high quality English beef derive much encouragement. The outlook for this industry can only be regarded as obscure. (Refs. 31 and 32).

The Midland Agricultural College, too, is responsible for an investigation of the economics of arable sheep farming in the East Midlands, dealing not only with costs and returns of breeding and feeding, but also with the place of sheep in the farm economy. The authors suggest that there is good cause for uneasiness on the outlook for arable sheep flocks. On the other hand, the figures they produce suggest the difficulty of generalisations, and that success or failure can depend on factors quite apart from costs and prices. Most important of these appears to be the extent of losses from disease, the incidence of which varies greatly in different flocks. Uneconomic flock size in relation to the labour involved

is another factor, for it may push up labour costs. These varied in this particular investigation from 9s. a head in flocks of 300 and over, to twice this amount in flocks below 150 head. A third cause of high costs may be due to folding root crops, and here again the small flocks are at a disadvantage because small root areas do not lend themselves to cost reduction by mechanisation of manual processes. (Ref. 33).

The position of the sheep farmers in the hill districts has caused them concern for some time past, and the conclusion of a study in the economic organisation of hill sheep farms in Wales is that many of them are too small to produce a turnover big enough for the reasonable remuneration of the labour engaged. "On economic grounds it seems established that it is necessary to increase the size of many of the smaller hill farms, not only of Wales but also of Scotland and England." (Ref. 34).

(*iii*) *Milk.* The study of milk production costs continues, as being a subject of major interest to farmers in nearly every part of the country. The figures are compiled for the summer and winter periods recognised in price-fixing arrangements, and for the farmer and for the student alike they are particularly instructive at the present time, when the scarcity of the usual feeding-stuffs is driving milk producers more and more to develop their own resources. Otherwise the published reports from the various centres follow the usual lines. Most of the investigations disclose considerable scope for improvement in the average yields of herds. A report on 60 herds in Devon and Cornwall, for example, shows an average yield of 546 gallons per cow. Another from Yorkshire shows a range from 915 gallons down to 379. While feeding costs may fluctuate more or less directly with milk-yields, many of the other items will vary inversely with them. (Refs. 35-39).

(*iv*) *Labour and Machinery.* An elaborate analysis of labour costs on Welsh farms in recent years throws light on the amount of the increase in real costs due to the rise in wage-rates. In the year 1939-40, labour per 100 acres of crops and grass, including regular employees and casual and paid family labour, was £194 ; in the year 1944-45 this had risen to £401, an increase of 107 per cent. This has reference to farm labour in general. The special labour problems of the dairy farmer have been the subject of study in the West of Scotland, where 186 farms have been examined. This study is unusual in that it takes the form of expressions of opinion by the farmers concerned, upon a set of questions put to them relating to labour problems in milk production. The answers are tabulated by districts. It was no part of the scheme of enquiry to ascertain the employees' views, but the employers' opinion may throw some light on a very difficult problem. (Refs. 40 and 41).

The effects of the sharp rise in wage rates have hardly been reflected so far in farm organisation. As farming departs more and more from the basis of family labour, and approximates ever more closely to conditions in the nation's other great industrial enterprises, so the tendency must be to speed up the mechanisation of the old manual processes. Shortage of man power during the war, together with the great increase in the area under cultivation, has done much in this way, and it remains to be seen whether the supply of contract machine-labour made available to farmers in recent years is to be a permanent feature of farm organisation in this country, or whether there will be a movement towards larger individual holdings on which the problems of capitalisation to provide mechanised equipment will be more easily solved. Whatever the outcome, however, it is clear that machinery costs and studies of efficiency in power farming are of first-class importance to-day as aids to farm management.

Tractor costs have been studied particularly at the East of Scotland College of Agriculture, where twenty-five different jobs performed by tractor power, both wheeled and track-laying machines, have been examined. They extend from beltwork and haulage to spraying potatoes and ploughing up sugar beet. Generalisations, of course, for application to the country as a whole, are impossible from this one set of figures, but farmers in the area

to which they relate may be advised to consider very carefully the report which has been issued. (Ref. 42).

A similar investigation on a smaller scale was the subject of a report from the West of Scotland Agricultural College. (Ref. 43).

More than any other machine operated by mechanical power, the combine-harvester has established itself. It is barely twenty years since the first harvester-thresher demonstration was organised in Hampshire, but in eastern Britain to-day the harvest on many farms would be impossible without the assistance which it provides. It is not merely a question of saving in cost, although this is said to be something like 25s. to 30s. an acre. It is a question of getting work done notwithstanding bad weather and the shortage of workers. The attention of arable farmers may be commended to a paper and discussions on harvesting by combine at a Crop-drying Conference at Birmingham last year, organised by the National Farmers' Union (Ref. 44). Scottish farmers interested in the subject should read a report on the work of combine-harvesters in south-east Scotland in 1944, issued by the Edinburgh and East of Scotland College of Agriculture. (Ref. 45).

Threshing in the stackyard by the machine is still the most general method, however, of dealing with the corn crop, and the Farm Economics Branch at Cambridge have done a service by a survey of the various methods and machines in use at the present time. Costs were confined to wheat and barley threshed from the stack, and the records were divided into three groups (*i*) contractor-owned British machines, (*ii*) farmer-owned British machines, (*iii*) farmer-owned American machines. Readers must be referred to the report for details, but it is somewhat disconcerting to note that threshing costs per quarter were something like 40 per cent. lower on the American machines, due mainly to their smaller demands upon labour. (Ref. 46).

Another Technical Bulletin issued by the National Farmers' Union deals with grass-drying in 1945, and is a summary of proceedings at a Crop-drying Conference to which reference has already been made. Grass-drying was introduced to farming with a flourish which early experience did not justify, but the product is far too good for the process merely to be written off in consequence. Progress is steady, if slow, but there is a limit to the amount of water which one unit of fuel can be made to evaporate, and the problem is how to get as near to it as possible. (Ref. 47).

(c) *Miscellaneous.*

Cambridge has used data supplied by the Farm Management Survey for a comparative study of changes in the economic organisation of agriculture during the war years. Comparisons are made of one year with the next, starting with the last pre-war year, and they include changes in cropping and stocking and also in the financial results, in the various agricultural districts which compose the Cambridge province. (Ref. 48).

The larger National Farm Survey has been used by workers at Wye college for a consideration of the efficiency of farm layout, and of the management of multiple farms. It is a commonplace that both farms and fields in most places remain to-day as they were laid out for very different farming systems, and often involve a high measure of inconvenience. The author of the Wye report is prepared to accept this, on the grounds that it would be more useful to bring the equipment of the present holdings up to date than to spend time on the more difficult task of reassembling them in more convenient units. Similarly, he is prepared to justify the management of multiple farms composed of scattered units. He thinks that a system by which four farms, say, have unified management at the head but diversified management on each unit is better than an equivalent acreage in one block and with unified control throughout. (Ref. 49).

III. MARKETING AND CO-OPERATION.

Little work has been published during the past year on marketing of farm produce or on co-operation amongst farmers for its production and sale. The reason is obvious, for the farmer has few marketing problems to-day. With regard to wool, however, a Committee was set up by the Minister of Agriculture and the Secretary of State for Scotland at the end of 1944, to examine pre-war arrangements for the marketing of wool and the changes introduced under war-time control. The Committee concluded from their evidence that a wool marketing scheme under the Agricultural Marketing Acts was undesirable, and that the first need was the constitution of a body, to be called the Joint Wool Council, for promoting better understanding and joint action between users and growers. Co-operation with Dominion and other wool-growers' associations is contemplated for certain purposes, but it is clear that the Committee have in mind a voluntary organisation dependent for its success as much on goodwill between all the parties to the wool industry at home and abroad, as on statutory authority. (Ref. 50).

A Committee set up by the Fabian Colonial Bureau, under the chairmanship of Lord Winster, has reported upon the whole question of co-operation in the Colonies. There is a survey of the movement in all the British dependencies, and information upon the emphasis which the different colonies have laid upon the various lines of organisation—credit and thrift, marketing, consumers' societies, and organisations for production including co-operative farming. On the whole, it is true to say that progress has been made, but as might be expected, it is slow and difficult, and failures have to be recorded. The Report concludes with recommendations for Government action in the future. (Ref. 51).

IV. LAND TENURE.

Colonial land problems are further in evidence in an account of the various land tenure systems published by the Agricultural Economist of Kenya Colony. In a small volume he has got together much information not easily accessible, on different types of tenure, tribal, feudal, share tenancy, cash tenancy, owner-occupation, etc. The dangers of the freehold system, of sub-division and fragmentation, of farm indebtedness amongst native races, are discussed, and the fruitlessness, often, of attempts to save the native from the exactions of usurers of various sorts. The author's best hope for the future would seem to lie in more intervention by a well-informed bureaucracy, for uncontrolled individualism in a backward country results only in the exploitation of the weak (Ref. 52).

C. S. ORWIN.

THE MALT HOUSE,
BLEWBURY,
DIDCOT

References

I. WORLD AGRICULTURE.

1. The World Food Shortage. *Cmd.* 6785. *H.M. Stationery Office,* 1946.

2. Second Review of the World Food Shortage. *Cmd.* 6879. *H.M. Stationery Office,* 1946.

3. Statistics and Documents relating to the World Grain Position. *Cmd.* 6737. *H.M. Stationery Office,* 1946.

4. Documents relating to the First Session of the Food and Agriculture Conference of the United Nations. *Cmd.* 6731. *H.M. Stationery Office,* 1946.

5. Land Classification, by G. V. Jacks. *Imperial Bureau of Soil Science,* 1946.

II. FARM MANAGEMENT.

(*a*) *The Farm Management Survey.*

6. Farm Management Survey of England and Wales. Preliminary Statement of Financial Results for 1,875 farms in 1943. Agricultural Economics Research Institute, Oxford.

7. Economic and Financial Results on 200 Farms in the Bristol Province. Year 1944-45, by L. J. Hewett. Agriconomica. University of Bristol, 1946.

8. Somerset Group: Comparative Tables of Farming Results for the cropping year 1944. Notes on Farm Economics, No. 22 University of Bristol, 1946.

9. Wiltshire Group: Comparative Tables of Farming Results for the cropping year 1944. By L. J. Hewett. Notes on Farm Economics No. 23, University of Bristol, 1946.

10. Worcester and Gloucester Groups: Comparative Tables of Farming Results for the cropping year 1944, by R. C. Broughton. Notes on Farm Economics, No. 24. University of Bristol, 1946.

11. Financial Results on 181 Farms in Devon and Cornwall for the years 1943/44 and 1944/45. By R. Henderson H. W. B. Luxton and E. E. Watkins. *Farmers Report No.* 44, University of Bristol, 1946.

12. Farm Management Survey Report (Shropshire and Staffordshire Report). University of Manchester, 1946.

13. Farm Management Survey 1944-45. *Bulletin* No. 28. Agricultural Advisory Department University of Manchester.

14. Financial Results on Farms in the Cumberland Plain. 1944. Report No. FMS. 17. University of Durham.

15. Financial Results on Farms in Weardale, 1944. Report No FMS. 18. University of Durham.

16. Financial Results on Stock Feeding Farms in South Northumberland, 1944. Report No. FMS 19. University of Durham.

17. Financial Results on Mixed Farms in South Northumberland, 1944. Report No. FMS 20. University of Durham.

18. Financial Results on Mixed Farms in Durham 1944. Report No. FMS. 21. University of Durham.

(*b*) *Costs of Production.*

(*i*) *Crops.*

19. Financial Results on the College Farms, XIII. Arable Land Crops 1939 to 1944, by James Wyllie. South Eastern Agricultural College, Wye, Kent.

20. Cost of Growing and Harvesting Oats, 1945. Final Report No. G.20. University of Durham.

21. Enterprise Cost of 1945 Oat Crop. Albert D. Imper and J. Clark. Economic Report No. 2. North of Scotland College of Agriculture.

22. Enterprise Cost of 1945 Potato Crop by Albert D. Imper and J. Clark. Economic Report No. 3. North of Scotland College of Agriculture.

23. Sugar Beet Costs and Returns, 1945. Farmers Report No. 62. University of Leeds.

24. Cost per Acre and per Ton of Growing Sugar Beet, 1945 Crop. Midland Agricultural College, Sutton Bonington.

25. Economics of the 1944 Flax Crop in the East of Scotland. Edinburgh and East of Scotland College of Agriculture.

26. Hay Costs 1945. *Report No. G.*17. University of Durham.

27. Hay Production Costs 1943-1945. *Farmers Report No.* 42. Bristol University, 21, Queen Street, Newton Abbot, Devon.

28. Crop Costing Studies No. 2: Crop 1945. *Report No.* 4, 1946. West of Scotland Agricultural College.

(*ii*) *Livestock.*

29. Uses of Bulls in Wales, 1935-36 to 1944-45. By J. H. Smith, University College of Wales, Aberystwyth.

30. An investigation into the Costs of Rearing Cattle in three areas of Devon. *Farmers Report No.* 46, University of Bristol, 21, Queen Street, Newton Abbot, 1946.

31. The Economics of Yard Cattle Feeding under war conditions, by W. Bond and S. M. Makings. *Survey Studies* 7. Midland Agricultural College, 1946.

32. Economic Aspects of Beef Production and Consumption, by J. J. MacGregor. Harper Adams Agricultural College, 1945.

33. The Economics of Arable Sheep Farming in the East Midlands, by S. M. Makings and A. J. Wynne. *Survey Studies* 6. Midland Agricultural College, 1945.

34. Hill Sheep Farms in Wales, by J. R. E. Phillips. University College of Wales, Aberystwyth, 1946.

(iii) Milk.

35. Milk Cost Investigation. General Report for Devon and Cornwall, 1944-45. *Farmers Report No.* 43. Bristol University, 21, Queen Street, Newton Abbot, 1946.

36. Milk Production Costs in Yorkshire. *Farmers Report No.* 61, University of Leeds, 1946.

37. Milk Production Costs on North Country Farms. Summer Period 1945, by T. Winter. *Report No. M.*21. University of Durham.

38. Farm Costs of Milk Production on North Country Farms, 1944-45, by D. H. Dinsdale and T. Winter. *Report No. M.*22. University of Durham.

39. Interim Report on Cost of Milk Production, Winter 1945/46, Edinburgh and East of Scotland College of Agriculture, 1946.

(iv) Labour and Machinery.

40. Farm Costs of Hired Labour in Wales during 1944-45, by J. H. Smith. University College of Wales, Aberystwyth, 1946.

41. Some opinions on Dairy Farm Labour Problems. *Report No.* 6. West of Scotland Agricultural College, 1946.

42. Economic Aspects of Farm Mechanisation. *Report No.* 1, 1944/45 Tractor Costs and Performance. Edinburgh and East of Scotland College of Agriculture.

43. Farm Power Studies No. 2 Tractor Costs. *Report No.* 7, 1946. West of Scotland Agricultural College.

44. Harvesting by Combine, by W. H. Cashmore. *Technical Bulletin No.* 5. National Farmers Union 1946.

45. Combine Harvesters in S.E. Scotland, 1944. Economic Aspects of Farm Mechanisation *Report No.* 2. Edinburgh and East of Scotland College of Agriculture, 1945.

46. Threshing by British and American Machines. *Farmers' Bulletin No.* 10. Cambridge University Department of Agriculture, 1946.

47. Grass Drying, 1945. by D. Fairclough. *Technical Bulletin No.* 5. National Farmers Union.

c. Miscellaneous.

48. Changes in the Economic Organisation of Agriculture. *Report No.* 29. University of Cambridge Department of Agriculture.

49. National Farm Survey. Results of some investigations in the Wye Province, by James Wyllie. S.E. Agricultural College, Wye, 1945.

III. MARKETING AND CO-OPERATION.

50. Report on Wool Marketing. *H.M. Stationery Office*, 1946.

51. Co-operation in the Colonies. A Report from a Special Committee to the Fabian Colonial Bureau. *George Allen and Unwin.*

IV. LAND TENURE.

52. Land Tenure in the Colonies, by V. Liversage. *Cambridge University Press.*

DAIRY FARMING AND DAIRY WORK

MILK PRODUCTION.

ONE of the most important features of agricultural production during the period of the war has been the national recognition of the importance of milk as a food, and, as a natural sequence, the emphasis on the need for increasing the production of milk to meet the demands of the liquid milk market at all seasons of the year. From 1941 onwards milk has been "priority product No. 1" on dairy farms.

The statistics published in the Annual Reports of the work of the Milk Marketing Board, which appear in the 'Home Farmer' of May each year, provide a measure of the increase in the number of registered producers selling milk by wholesale and of the number of licensed producer-retailers in England and Wales. These numbers for the years 1939 to 1946 are summarised below and the quantity of milk sold off the farm each year is also given.

NUMBERS OF REGISTERED MILK PRODUCERS.

Year ending 31st March	Wholesale producers	Inc. or Dec. over previous year	Producer Retailers	Inc. or Dec. over previous year	Total Reg. producers	Total Milk sold. (Million galls.)
1939	95,412	—	61,956	--	157,368	1,080
1940	97,807	+ 2,395	60,969	— 987	158,776	1,109
1941	109,028	+11,221	62,756	+1787	171,784	1,060
1942	119,588	+10,560	62,221	— 535	181,809	1,040
1943	125,750	+ 6,162	58,115	—4106	183,865	1,111
1944	128,429	+ 2,679	55,943	—2172	184,372	1,180
1945	131,254	+ 2,825	53,480	—2463	184,734	1,188
1946	131,047	— 207	50,599	—2881	181,646	1,238
Increase or Decrease in 7 years		+35,635 +(37.3%)		—11,357 —(18.3%)	+24,278 +(15.4%)	+158 +(14.6%)

The above table shows the extent of the increase in the number of producers selling milk by wholesale and an appreciable reduction in the number of producer retailers. It must not be inferred that the increase in the number of wholesale producers means a corresponding increase in the number of herds of cows. It is well known that this increase has arisen mainly by the transference to the liquid milk market of milk from herds where formerly cheese and butter were made.

The increase in the demand for liquid milk has also caused a marked change in the utilisation of milk sold off the farm. In 1939 and 1940 some 30 per cent. of the total output was manufactured into various products, whereas in 1942 to 1945 only some 10 per cent. was used in this way. In spite of this change in utilisation, the increase in the liquid demand was such that there was insufficient milk available during the winter months and the sale to

adults had to be restricted to enable the priority requirements of infants, children and special classes of the population to be met. In the 'Home Farmer' of May 1945 figures are given for the total sales of milk by registered producers during the summer and winter periods and it is interesting to note, that, although the total sales in both periods have arisen appreciably, the ratio between summer and winter sales has remained almost constant. In the year ending March 31, 1939 out of every 1,000 gallons, 451 were produced during the winter six months, and in the following six years the winter sales per 1,000 gallons were respectively 430, 440, 443, 444, 448, and 450.

In view of the continuing demand for liquid milk it is of interest to note from the table on p. 40, that in 1946 the total number of registered producers decreased slightly. This decrease may be more than made up during the current year but it must be realised that a number of factors tend to lessen the enthusiasm of farmers for milk production. These include the continuing difficulty of obtaining sufficient labour on the larger dairy farms, the reduction in the supplies of rationed feeding stuffs (which must almost inevitably cause a decrease in output on many farms) and some dissatisfaction regarding the price to be received for milk. The full effect of these factors will not be known until the winter of 1946-47, but it is obvious that if the number of herds devoted to milk production does not increase, the additional output of liquid milk required to enable the rationing of supplies to adults during the winter to be dispensed with can only be obtained by achieving higher average yields. In the following pages some of the work in progress in this and other countries designed to attain this end will be reviewed.

MILK RECORDING—NATIONAL MILK RECORDS.

The systematic recording of the milk yield of cows under the National Milk Records scheme operated by the Milk Marketing Board continues to increase. When the Board took over the supervision and development of milk recording from the Central Council of Milk Recording Societies in January 1943, the number of recorded herds was 4,120. By March 1945 the number had risen to 16,700 of which 13,300 had adopted the Senior Scheme and 3,400 the Junior Scheme, and by March 1945 the number in both schemes was 19,200. The membership of the Junior Scheme has continued to decline, mainly through the transference of members to the Senior Scheme. This change-over is to be welcomed as it indicates that the greater frequency of check visits, the facilities for butter-fat testing and the availability of certificates of the records of individual cows are increasingly appreciated. There has also been a marked increase in the number of samples submitted for butter-fat testing and, fortunately, most of the difficulties encountered during 1943 and 1944 have been to a large extent overcome.

The Annual Report on Milk Recording for the milk-recording year ended 1st October 1945 (Ref. 1) contains much interesting information on the progress of recording and the average milk yields in the different regions in England and Wales, and on the average yields of the chief breeds of dairy cattle. In one table is shown the number of recorded herds and cows in each region and in each county, and the percentage which these numbers represent of the total number of herds and cows from which milk is sold. For the country as a whole 11.1 per cent. of the herds and 17.0 per cent. of the cows were recorded during the year, but there was a marked variation between regions and counties. Thus, in the South-Eastern Region, which comprises the counties of Essex, Herts. Kent, Surrey and East and West Sussex, 31.6 per cent. of the herds and 39.8 per cent. of the cows were recorded. The best results are found in Surrey where the figures are respectively 40.7 per cent. and 47.8 per cent. At the other end of the scale the Far Western Region, comprising Devon and Cornwall, and the Northern. Region, comprising Lancs. Cheshire, Derby and Staffs., have less than 7 per cent. of their herds and less than 10 per cent. of their cows recorded.

With regard to milk yields the average yield per cow for the milk recording year ended October 1st for 11,458 "full year" herds was 6,923 lb. The regions with the highest averages were the Eastern (comprising Lincs., Cambridge, Norfolk and Suffolk) and the South Eastern, whilst amongst the counties, Essex led with an average of 7,983 lb. It is interesting to note the much greater popularity of recording and the attainment of higher average yields in the counties on the eastern side of England, where dairy farming has been developed in the course of this century, in contrast to the lesser degree of popularity and the lower average yields in those western districts where dairy farming is traditional and the soil and climate are considered more favourable for milk production.

The average yield for the milk recording year of the chief milk producing breeds is also given in the report together with some information on the range of fat percentage for the different breeds. A summary of the average yields is given in the following table for those breeds in alphabetical order which had more than 100 herds recorded together with a percentage distribution of percentage of fat.

Breed	Milk Yields		Fat Percentages				
	No. of Herds	Aver. Yield lb.	No. of cows tested	Proportions			
				under 3.50	3.50 and under 4.00	4.00 and under 4.50	4.50 and over
				%	%	%	%
Ayrshire	991	7,015	12,140	20 3	49.3	25.9	4.5
Friesian	2,184	8,189	21,665	56.8	35.9	6.4	0.9
Guernsey	686	6,778	5,842	1.2	9 6	30 8	58.4
Jersey	504	6,402	4,030	0.4	2.1	12.9	84.6
Red Poll	266	6,873	2,063	32 8	47.5	17 1	2.6
Shorthorn	4,458	6,430	13,040	37 6	47.5	13 0	1.9
South Devon	165	5,828	140	3.6	25.7	40.0	30.7
Mixed	2,009	6,279	498	31.1	37.0	24.1	7.8
All Breeds	11,458	6,923	59,832	34.8	36 7	15.2	13.3

The average yield of 6,923 lb. for 11,458 herds compares favourably with an average of 6,821 lb. for 6,974 herds in the preceding year. During the war years no figures were published on the average yield but it is interesting to compare the averages for 1944-45 and 1943-44 with those published by the Ministry of Agriculture in the years immediately preceding the war. For the two years ending October 1st 1936 and 1937 the average annual yields for about 80,000 cows was 7,654 lb. and 7,453 lb. respectively.

The Milk Marketing Board has announced that, after careful consideration of the subject, the calculation of the weight of milk produced by each cow in the milk recording year will be discontinued after October 1st 1946 and individual cow records will be given only according to the lactation period yield. This decision implies that averages comparable with those quoted above will not be available after the year ending October 1st, 1946. It is proposed that herd averages will be worked out for all cows which end a lactation period within the milk recording year but as these periods may end any time between October and September, the herd averages will not be for fixed and uniform periods of time as has been the case in the past. The statement of the yield of an individual cow on the basis of lactation periods fits in with the natural calving and milking cycles and with Breed Society requirements but it remains to be seen whether herd averages based on lactation yields will provide an acceptable means of comparison between herds, districts and breeds.

THE STUDY OF MILK RECORDS.

The Milk Marketing Board has also stated that it is establishing a Bureau of Records to provide more information than is at present obtainable on the life-time records of individual cows, on cow family records and on records of the progeny of bulls. A service of this nature will be a great help and will be much appreciated by herd owners and breed societies. In a few other countries some progress has been made in the development of this type of work and recently a report (Ref. 2) has been issued by the New Zealand Dairy Board describing the methods used and the results obtained to the end of the 1945 season on Sire Surveys and on the institution of a Register of Lifetime Merit for pedigree cows. On methods it contains much of value to all interested in the full utilisation of milk records for the improvement of British dairy stock, but it rightly points out that conditions in New Zealand differ appreciably from those in other countries, as milk production is carried on under almost ideal conditions, namely, a well distributed rainfall and a mild winter, which enables cows to be kept on grass practically the whole year round ; further, milk production is concentrated into the most suitable period of the year and is not complicated, as in this country, by the need for a high level of production during the winter months to meet the demands of the liquid market.

Progeny Recording. The New Zealand method of stating sire survey (or progeny test) results includes a *preliminary* statement issued to the owner of the bull when at least 10 of his daughters have completed one lactation ; an *intermediate* statement when at least 8 of these daughters have completed a further lactation and a *final* statement when at least 6 of the daughters have completed three lactations ; also, all daughters for which records are available must be included in all stages of the survey. The lactation yields are the production of milk and butter fat for the first 305 days of the lactation ; corrections for age are applied to the lactation yields made when the cow is two years and three years old and any obviously subnormal lactations because of sickness, abortion, etc. are excluded. In the preliminary and subsequent statements the yields of milk and butter of the dams are also given so that the extent to which the daughters are superior or inferior to their dams can be noted.

An interesting and important conclusion has been arrived at from the study of 2,386 sire surveys. It has been found that only a small percentage of the bulls mated with high-producing cows have been able to beget daughters better than their dams, for example, of 185 bulls mated with cows producing 400 lb. or more butter fat per lactation, only 11 (or 6 per cent.) begot daughters which were superior to their dams. On the other hand, a large percentage of the bulls mated with low-producing cows had daughters which were better than their dams, for example, of 384 bulls mated with cows producing below 300 lb. butter fat per lactation, 263 (or 68 per cent.) begot daughters which were superior to their dams. These figures illustrate the great difficulty which confronts owners of high-producing herds in finding bulls which will bring about further improvement or even maintain the standard already attained. There is no doubt that the same difficulty confronts owners of high-producing herds in this country and the New Zealand conclusion that further improvement depends on the use of methods of selection which will enable the owners of high-producing herds to purchase or breed sires capable of holding these high levels of production is equally applicable here.

The following terse statements in the report also appear worthy of quotation :—

" The four qualities necessary for a sound dairy cow are :—Sound butter-fat production qualities ; fertility—ability to calve regularly ; resistance to disease—sound constitution and long working life."

" Test your bull. During his lifetime 40 to 50 heifer calves are reared from the average bull compared with 2 to 3 calves from the average cow."

"The next best bull to a proven bull is the son of a proven bull from a line of sound female ancestors."

Life-time Production of Cows. In addition to the progeny testing of bulls the New Zealand Dairy Board has also instituted a Merit Register for cows in order to make known those cows which have attained a high level of production over a period of years. This register consists of two parts—an intermediate merit register and a life-time merit register. To qualify for entry in the first a cow must have produced in three successive lactations during a period of three successive years a total production of at least 1,200 lb. of butter fat, such total quantity to be produced before the animal reaches the age of eight years; further, in each of these lactations at least 350 lb. butter fat must have been produced, except in the case of a first lactation commencing under the age of 2½ years, when the minimum is 300 lb. butter fat. The production in each lactation is based on the first 305 days. To qualify for entry in the life-time merit register a cow must have a total production of at least 2,500 lb. butter fat in not more than eight successive years; a cow which has produced at least 4,000 lb. butter fat in a period of not more than ten successive years is credited with an "elite" entry in the register. In the report referred to details are given of the production of 1,054 pedigree cows (of the Ayrshire, Friesian, Jersey and Milking Shorthorn breeds) and of 692 grade cows which have qualified for the Life-time Register, and of these 82 and 67 respectively have attained the "elite" standard.

The United States Bureau of Dairy Industry also collects and classifies the records of cows in the Dairy Herd Improvement Associations now operating in every State. Records of the identity of the bulls used and of the production of their daughters are forwarded to the Bureau, where they are permanently filed to form family-tree records; the production records of more than 700,000 cows are now available for study.

In order to obtain progeny records, as soon as the production records of five or more daughters of a bull have accumulated in the Bureau's files they are compared with the records of their dams to get an indication of the value of the sire. Each year the Bureau publishes a list of the sires for which dam-daughter records were tabulated during the preceding year. These lists are most helpful sources of information for dairy farmers who are looking for bulls to improve the production of their herds. It is pointed out in a summary of this work (Ref. 3) that this tabulation and study of proved sire records can also assist the thousands of herd owners who keep no records to obtain better bulls. Most of the State Extension Services maintain lists of sons of proved sires available for sale and many of them have schemes for placing these sons in farm herds soon after they are born. Further, the Bureau of Dairy Industry has demonstrated the benefits from using bulls which are the sons of proved sires by placing these sons on commercial farms. In 15 herds where 3 or more young bulls (Holsteins, *i.e.*, Friesians) bred at one of the Bureau's experimental stations have been used the records obtained show that the original 265 cows in these 15 herds averaged 411 lb. butter fat; that 265 daughters of these bulls averaged 461 lb.; that 172 daughters with two top crosses of proved sire's sons averaged 486 lb. and that 67 daughters with three top crosses averaged 541 lb. butter fat. It is claimed that these results provide evidence that the superior genetic qualities for high production which have been developed in the experimental station herd can be introduced into commercial herds with assurance that the production level of such herds will be raised if adequate environmental conditions are provided.

BREEDING OF DAIRY CATTLE.

The need for more milk to meet the consumer demand in this country has led to a widespread awakening of interest in the improvement of the yields of our herds by better breeding methods. While indiscriminate crossing of breeds has been condemned because it can only lead to mongrelisation, deliberate crossing with a view to grading-up a herd to another

breed type has probably increased and in many herds a definite policy of improvement by the use of more carefully selected bulls of the same breed has been adopted.

The interest shown by the commercial farmer in this subject is also indicated by the marked increase in the membership of the various breed societies and by the numerous requests from all parts of the country for the establishment of artificial insemination centres. With regard to the latter, at the time of writing there are two centres in operation under the direct control of the Ministry of Agriculture, at least four centres under local control, and four centres under the control and direction of the Milk Marketing Board. All these centres operate according to the Artificial Insemination (Cattle) (England and Wales) Regulations which came into force on November 1st 1943. (See this Journal, Vol. 105, 1944, p. 179). The Milk Marketing Board are proceeding with plans for the establishment of eleven other centres in different parts of England and Wales.

The relative value of different methods of mating—in-breeding, line breeding and out-crossing— provides a topic for many discussions amongst herd owners, whether their herds be maintained through the use of a bull chosen by the owner himself or by the insemination of the cows with semen from the bulls maintained at an artificial insemination centre. Sometimes the value of these discussions is greatly lessened by a lack of clarity as to the meaning of the terms used and it may be helpful to give definitions which are widely, if not universally, accepted.

In-breeding. (sometimes called close-breeding) is the mating of closely related animals such as sire and daughter, dam and son and full brother and sister. *Line-breeding* is the mating of animals of wider degrees of relationship than those included under in-breeding and is generally directed towards keeping the relationship high to some desirable ancestor or line of ancestors. *Out-crossing* (sometimes called out-breeding) is the mating of animals that are members of the same breed but which have no near relationship. This latter phrase can be taken to mean no relationship within the first four to six generations. This method of mating may be the regular practice in a herd or may be temporarily adopted in an in-bred or line-bred herd to introduce new qualities or additional vigour.

Experimental evidence on the results of the different methods of mating in cattle is very limited in quantity and is obtained from reports of work done in other countries. A description of one such experiment is given in a bulletin issued by the New Jersey Agricultural Experiment Station (Ref. 4). In the Holstein-Friesian herd maintained at the station a programme of in-breeding and out-breeding has been followed for ten years in an endeavour to concentrate inherited factors for high butter fat and milk production. The in-breeding consisted of sire-daughter matings, brother-sister matings, matings with less than 50 per cent. of the same blood and out-breeding. The influence of in-breeding as compared with out-breeding was studied by means of records of growth, production and the health of the animals.

The results in the first ten years of this experiment have not led to any definite conclusions affecting the practice of in-breeding in general. In-breeding to a considerable degree did not reduce size and in-bred animals were generally superior to out-bred animals in type. No statistical difference in the percentage of fat was found between the two groups, but the out-bred cows showed slightly less total milk and total fat production. The primary result of the experiment is stated to be the development of superior in-bred sires; these have demonstrated a marked prepotency for desirable growth, type, butter fat percentage and milk production, and it is suggested that this is due to the homozygosity (greater genetic purity) obtained by in-breeding. The use of in-bred sires of the best ancestry usually leads to consistent transmission of the good qualities of the sire's family.

The results of another in-breeding experiment are summarised in the report of the United States Bureau of Dairy Industry already referred to (Ref. 3). In this case a care-

fully chosen Holstein-Friesian bull was used in a poor herd of mixed breeding and the resulting daughters showed a great improvement over their dams ; the daughters were then mated with their own sire and further improvement, but less in degree, resulted. In-breeding was continued by the use of in-bred sons and grandsons, etc., of the first sire for some thirty years and it was noted that as the intensity of in-breeding increased there was a constant and unmistakable decrease in the weight of calves at birth, the mortality was greater, rate of growth slower, size at maturity declined, vigour was impaired and production decreased ; fertility, as measured by the number of services required for conception, was also affected adversely but not to a serious extent. When the inbred cows were mated with unrelated bulls of the same breed (*i.e.*, when an out-cross was introduced) the offspring approached normality in every respect, which indicated that the bad effects of in-breeding were almost completely removed by a single out-cross.

The slow rate of reproduction, the small number at a birth and the value and cost of maintenance impose very great difficulties on the carrying out of reliable breeding experiments with dairy cattle (and other farm live stock). Much experimental work has, however been done with small animals, such as rats and guinea pigs, and some general conclusions extracted from a most instructive book by Rice (Ref. 5), will shed more light on the probable result of methods of mating as practised in stock-breeding. (The phrases in brackets in the following quotation are inserted by the reviewer to define the terms used).

" In-breeding in itself does not create any new genes (units of inheritance passed from parents to offspring), nor for that matter does any system of breeding. All that any system can do is to recombine the genes already present into new combinations. With out-breeding we tend to keep our live stock heterozygous (impure in respect of many genes and the qualities which arise from them). With in-breeding, we make them more homozygous (the opposite of heterozygous). If we have a preponderance of good genes and gene combinations in our stock to start with, in-breeding plus selection will increase the good qualities we already have. If we have a preponderance of poor genes and gene combinations to start with, in-breeding will increase the poor qualities we already have." (p. 504).

" The man with just average live stock should, of course, not practise inbreeding. The fact that his stock is average means that it has a goodly share of undesirable genes, which in-breeding would make homozygous and therefore worse. For average live stock, out-crossing would seem to be a better system, for unrelated animals would have less likelihood of carrying identical poor genes. The man with better than average livestock should do some in-breeding. The fact that his stock is above the average merit of the breed means that a random selected unrelated animal will have a tendency to pull his herd or flock back toward the breed average. Since many breeders are still shy of the word in-breeding, we will say that the better than average breeder should practise line-breeding, which of course is a form of in-breeding, but a term which does not have the same fearsome connotations as in-breeding. Every breeder should try to buy his males in the best available family in his breed. In the present state of our knowledge, the genetically best families in any breed are not easy to know and one must be wary of advertising and " ballyhoo." Assuming one does buy a sire in a really good family, then generally speaking, he should try to stay in that family, intensify its good qualities through line-breeding and weed out the poor genes." (p. 512).

Fertility of Bulls. The ability to get cows in calf has always been an important factor in herd management and in milk production. It will be obvious that the greater the dependence on any one bull or group of bulls the more important does the maintenance of a high rate of fertility become It follows therefore that with the increase in the number of artificial insemination centres and the dependence of an increasing number of herd owners on a supply of fertile semen from these centres, the fertility of the bulls kept becomes a point of major importance.

The fertility of a bull is usually measured by the ratio between services and pregnancies, but there is as yet no generally accepted measure of fertility. In respect of artificial insemination the statement is frequently made that the fertility rate is approximately the same as with natural mating. But what is the fertility rate with natural mating ? No information based on carefully collected data from a number of British farms is available. Information from the United States quoted in this review for 1931 (Ref. 6) was to the effect that over a period of 29 years in one herd where contagious abortion was prevalent the number of services of fertile cows for each conception was 2.52 ; in seven other well-managed herds the number of services for each conception was 1.90 with a range within the seven herds of 1.61 to 2.25.

In a recent report of investigations being carried on by the New Zealand Dairy Board (Ref. 7) a summary is given of the information collected over a period of five years. The data were obtained from selected farmers who had agreed to keep complete and accurate details of all services in their herds and who were following a strict practice of hand-serving of cows. It is stated that the object of this work is to discover what are the normal conditions within the industry and to ascertain the general nature and the extent of the sterility problem in typical herds as a guide to future research and also to provide information on several practical problems that arise in the extension of the use of proved sires and in connection with the operation of artificial insemination centres.

In this New Zealand work the fertility rate or index is calculated on the basis of matings per conception for all fertile cows in the herd ; all cows which were not in calf at the end of the mating season were excluded. It is explained that the complete mating season is approximately from early October to early January with about 70 per cent. of the matings concentrated into October and November.

The data for the 5-year period include 761 herd years and 41,807 cows. Of this number 38,709 were got in calf with an average of 1.50 services per conception ; 3,098 (or 7.4 per cent.) cows were not in calf at the end of the mating season. An analysis of the services of the fertile cows shows that on the average 67 per cent. were got in calf at the first service, 21 per cent. at the second, 8 per cent. at the third, 3 per cent. at the fourth and 1 per cent. at the fifth or later service.

The relation between the age of the bull and the fertility ratio was also studied. This is a matter of definite importance in relation to the retention of bulls until they can be proved by the records of their daughters both under normal farm and under artificial insemination conditions. The results obtained are so interesting that the table in which they are given is reproduced here.

ANALYSIS OF BULL FERTILITY ACCORDING TO AGE.
(Five Years' data 1939-40 to 1943-44).

Age of Bull	No. of Bulls	Matings to Fertile Cows	Total cows in calf	Fertility Index	Aver. No. of cows in calf per Bull	Fertility Index inc. Empty Cows
1 year	125	3,098	2,012	1 54	16	1 78
2 years	240	8,817	6,001	1.47	25	1 69
3 „	246	10,224	7,003	1.46	28	1 68
4 „	198	8,207	5,593	1.47	28	1 69
5 „	167	7,173	4,647	1.54	28	1 79
6 „	102	3,824	2,467	1.55	24	1 85
7 „	70	2,688	1,777	1.51	25	1.78
8 „	34	1,161	715	1 62	21	1 89
9 yrs. & over	47	1,705	997	1.71	21	1.91
Total	1,229	46,897	31,212	1.50	25	1.73

The results given above show that under New Zealand conditions the fear of a serious average decline in fertility prior to the age of at least 8 years is unfounded in practice and should certainly not be a general cause of disposal of bulls.

The report points out that the results obtained refer to the fertility of the bull under natural conditions in typical herds and recognises that artifical insemination makes demands of a different nature. These demands include the production of adequate quantities of semen of a satisfactory standard at regular intervals (as contrasted with approximately three months of intensive service and nine months comparative rest) and the power of adaptation to the conditions of housing, handling and semen collection which prevail at an insemination centre.

In due course information will, no doubt, be obtainable regarding the fertility rates at the different centres in England and Wales. Each centre must study the performance of its own bulls and will naturally endeavour to obtain good results. In addition to what may be called the natural fertility of a bull, a high standard of technical skill on the part of the operator (both collector and inseminator) is essential, but there are indications that it is easier to attain and maintain a successful level of operative efficiency than it is to keep a stud of bulls in good working condition month after month.

LABOUR SAVING ON DAIRY FARMS.

The difficulty of getting sufficient labour to carry out the seven-day-a-week work on dairy farms, together with the high rate of wages and the large numbers of hours which rank as overtime, makes all dairy farmers who require employees give ever-increasing attention to the organisation of the daily routine and to the adoption of equipment, methods and devices which will save time or make the work less laborious.

In factories and workshops the layout of the plant and the order of operations has been carefully studied and alterations made to enable time to be saved or used more efficiently, but little or nothing has been done on farms to achieve the same ends. There is no doubt that much could be done by each owner or manager giving the subject detailed consideration.

An illustration of the way in which this problem can be tackled and of the results which can be achieved is given in a bulletin issued by the Vermont Agricultural Experiment Station (Ref. 8). With the co-operation of the occupier of a farm of 150 acres —made up of 33 acres under crops and hay, 75 acres pasture and 42 acres woodland—on which a milking herd of 22 cows was kept, a member of the Experimental Station staff visited the farm at intervals and recorded the time taken for each of the various items of work, the distance travelled and the routes followed in the farm yard and in the barn in which the stock were housed on the ground floor and hay stored in a loft above. The barn was equipped with electric light, milking was done by machine, and running water was available in a tub in the yard and adjoining the milk house, which was 50 feet from the south end of the barn. In 1942, when this study was made, all the work on the farm was done by the occupier except for assistance when making maple sugar in the spring and when filling the silo.

After the investigator had studied the data he had collected with the aid of a plan showing the internal arrangement of the cowstalls, bull box, horse stalls, silo, sawdust for litter, hay chute from the floor above, etc., and the places where movable equipment such as a wheel-barrow, forks, shovels, etc. were usually kept, he made suggestions to the occupier as to changes which would save time. These suggestions were discussed, modified if necessary, and when agreed to were put into operation.

The various changes and adjustments were put into effect over a period of about four months from June 1942. They were grouped under four general headings, (1) Rearrangement of the stalls, etc. in the interests of convenience, (2) rearrangement of work routines

to economise time and distance, (3) improvement of equipment to make it better suited to the job for which it is used, and (4) convenient positioning of tools and supplies.

The bulletin contains a detailed description of the various changes introduced and how they reduced the time previously given to them or reduced the distance travelled.

The summary states that the time spent on the dairy farm " chores " (all the dairy farm jobs which have to be done daily or at intervals) was reduced from 5 hours 44 minutes to 3 hours 39 minutes daily, a saving of 2 hours 5 minutes, and the travel was reduced from $3\frac{1}{4}$ to $1\frac{1}{4}$ miles daily, a saving of 2 miles. The greatest reduction in time took place in milking operations, and particularly by lessening the average time the milking machine was on each cow from 8 minutes to 4 minutes.

It is claimed that a study of the procedure and the introduction of changes according to the internal layout and in the methods followed on many American farms will bring about definite savings in time and enable the worker to complete his duties with less fatigue.

There are many farms in England and Wales where the layout of the buildings and the internal construction and equipment are capable of great improvement. Indeed, improvement is essential to enable a satisfactory standard to be attained in herd health and management and in the keeping qualities of the milk produced. When improvements are being considered it is imperative that the labour-saving aspect should be carefully considered as well as compliance with local or national regulations. A study of a few English farms on the lines described above would be most helpful in the solution of a difficult and common problem.

JAMES MACKINTOSH.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING,
SHINFIELD, READING.

References

1. National Milk Records. Annual Report for England and Wales for the year ended 1st October 1945. *Milk Marketing Board, Thames Ditton, Surrey.*
2. WARD, A. H. New Zealand Dairy Board Sire Survey and Merit Register. *Issued by the Herd Recording Council. N.Z. Dairy Board, Wellington, N.Z.* 1945.
3. Report of the Bureau of Dairy Industry. *United States Department of Agriculture,* September, 1943.
4. BARTLETT, J. W. and MARGOLIN, S. A Comparison of Inbreeding and Out-breeding in Holstein-Friesian Cattle. *Bull.* 712. *New Jersey Agricultural Experiment Station,* 1944.
5. RICE, V. A. Breeding and Improvement of Farm Animals. (750 p.). *McGraw-Hill Book Company,* 1942.
6. See *Agricultural Research in* 1930. pp. 47, 48.
7. New Zealand Dairy Board Twentieth Annual Report for the Twelve Months ended July 31st, 1944.
8. CARTER, R. M. Labour saving through farm job analysis. 1. Dairy barn chores, *Bull.* 503. *Vermont Agric. Expt. Station,* 1943.

THE FEEDING OF LIVESTOCK

NUTRITION OF DAIRY COWS AND BEEF CATTLE.

Iodinated protein as a stimulant of milk production. In this *Guide* for 1944 brief reference was made to a preliminary report on work which had been carried out in this country on the use of iodinated proteins as supplements to the ration of dairy cows. A full report has now been published in a series of nine papers which deal with the preparation, assay and biological effects of such materials. In two of these papers Blaxter (Ref. 1) reports the results of practical trials with heifers and cows. Iodinated proteins were made from ox blood, ardein (a protein from earthnuts) and casein and fed at different levels to heifers and cows at various stages in lactation. It was quickly found that there was considerable variation in the potency of such preparations, and whilst a determination of the acid-insoluble iodine in the preparation gave an approximate indication of the effect likely to be produced on the milk yield, etc., of dairy cows, a closer agreement with the results of practical feeding tests was obtained if the materials were submitted to a biological assay carried out with Xenopus tadpoles.

Of the three types of iodinated protein tested the most satisfactory results were obtained with iodinated casein although one preparation of iodinated ardein produced good response. When these materials were fed to dairy cows, either out at grass or during stall feeding, at a stage just past the peak in lactation, the response for each preparation was roughly proportional to the amount fed, within a range of stimulation of 16—33 per cent. The maximum effect was obtained when 50g. (1¾ oz.) of the most active iodinated ardein or 30 g. (1 oz.) of the most active iodinated casein was fed daily. Accompanying the rise in milk yield there was a rise in the percentage of fat in the milk and hence a still greater rise in the yield of fat. The response to iodinated protein was intimately related to the stage of lactation, the response being small in early lactation, non-existent at the end of lactation and most marked at mid-lactation. The highest stimulation of lactation was accompanied by severe symptoms of hypermetabolism, namely, marked rise in heart rate, respiration rate and to a lesser extent in body temperature, and a marked loss in body weight (reaching in one case to 115 lb. in 7 weeks) and a general loss in condition. These effects could be lessened if the amount of iodinated protein fed was kept down to a level such as to produce a stimulation of only about 20 per cent. and attention was paid to housing. The weight loss

was in part, but not entirely, made good in a post-period of 3 weeks. In some of the experiments there was definite evidence that the iodinated proteins were unpalatable and that the animals showed symptoms of iodism, especially where larger amounts of the material were fed. It is stated that there was no evidence of permanent injury to cows or calves and that on cessation of treatment recovery was rapid but it must be borne in mind that these were only short-period experiments carried out with only small groups of animals.

In this connection it may be noted that both the Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland have stressed this latter aspect of the work and stated that, in the light of present knowledge, the general use of these materials could not be recommended and that, until further trials have been carried out, it is not intended that iodinated proteins should be made generally available. They also indicate that the economic aspect of the problem would require consideration.

Acetonaemia. A study of the seasonal and geographical occurrence of acetonaemia in cows in the south-eastern part of the U.S.A. indicates that this trouble is due to vitamin A. deficiency and two workers have independently reported satisfactory results by administration of massive doses (250,000 I.U.) of vitamin A. twice at 12 hour intervals, recovery being complete within 24 hours. The ailment is considered to be definitely associated with a lack of good pasture and/or good roughage.

General. Loosli *et al* (Ref. 2) report a marked detrimental effect resulting from reducing the roughage intake of dairy cows. When the supply of hay was reduced to 5 lb. or less daily for cows, mostly in an advanced stage of lactation, and their energy requirements were made good by additional grain mixture, the percentage of fat in the milk and subsequently the milk yield showed significant falls. When the hay intake was restored to 16 lb. the fat percentage returned to normal but there was no rise in milk yield.

Thomas (Ref. 3) as a result of wartime experience in cattle feeding reports that pasture feeding was moderately successful but that yard feeding was generally carried on at a loss. He suggests the greater use of protein-rich farm crops such as kale, cabbage, beans, and mixtures of beans and peas.

Sperm production by bulls. From Russia appears a report of work carried out in 1941 in which it is shown, from short period feeding trials with pure-bred Shorthorn and Aberdeen-Angus bulls which were used intensively for artificial insemination, that supplementing their diet with 20 per cent. of wheat germ concentrate gave an increase of 32 per cent. in sperm concentration, 31.5 per cent. increase of spermatozoa in ejaculates and a 63.6 per cent. increase of sperm viability. The sperm motility and libido of the bulls were also improved. The beneficial effects appeared about 25-30 days after the beginning of the feeding. It is recommended to add 800—1,000 g. (*i.e.*, up to 2 lb.) of wheat germ to the daily ration of breeding bulls.

NUTRITION OF SHEEP.

Recent trials in America point to the desirability of giving special attention to the feeding of ewe lambs during their first winter. Lot-fed lambs, receiving alfalfa hay during their first winter, showed a fuller development of their reproductive tract than corresponding lambs fed solely on open winter range. This difference was maintained in the second year.

Swayback in lambs. Hunter, Eden and Green (Ref. 4) report that, on some farms in Derbyshire, the recommended treatment of copper feeding to pregnant ewes appeared to be of little practical value. This may have been due to the fact that copper licks were not necessarily regularly consumed by all the ewes. The prophylactic value of copper has accordingly been re-examined. Investigations were conducted on five farms and various mineral supplements were tested. The results confirm that fortnightly dosing of the ewes with 0.5 g. ($\frac{1}{60}$ oz.) of copper sulphate had a marked beneficial effect in reducing the incidence of swayback but that other trace elements *e.g.*, iron, manganese, cobalt and

iodine in combination were not effective. On eighteen other farms where the ewes had access to commercial copper licks the incidence was 74 cases out of 1,170 lambs and 54 out of the 74 cases occurred on three of the farms. It is considered that the safest treatment is dosing fortnightly, or even more frequently, with 0.5.g. copper sulphate. Failing this, copper licks should be used, but their copper content should be raised from the 0.3. per cent. used up to 1-2 per cent. It would appear that daily intake of copper is not the only factor in the etiology of the disease since 40 ewes, which had given swayback lambs in the previous year, were taken to Weybridge after tupping and fed on a diet of crushed oats and oat straw, alone or supplemented with copper or with other trace elements, and gave birth to normal lambs, not one case of swayback occurring, although the daily copper intake of the ewes was only about one-third of that of ewes grazing on Derbyshire pastures.

NUTRITION OF THE PIG.

Breeding capacity and milk production in relation to plane of nutrition. Fishwick (Ref. 5) has drawn attention to the importance of adequate nutrition during early life of gilts being reared for breeding. He used two groups (of 13 each) which had been matched into pairs at 8 weeks of age. Group I were well fed from birth so that they grew steadily until they were served at 9 months of age. Group II were kept on a low plane of nutrition from 8—12 weeks of age so that the animals grew slowly and lost condition, and then during the next 4 weeks their standard of nutrition was built up until it attained that of Group I and from then on it was fed as Group I and the gilts were served at 9 months of age. At farrowing the gilts produced in Group I were longer in the body and lighter in the fore-end than those of Group II. In Group I 13 first litters comprising 131 young were produced as compared with 10 first litters (3 were barren) comprising 88 young in Group II. The weights of 5 pairs of comparable litters, in 4 of which pairs the numbers were equalised within 24 hours of birth, at 8 weeks showed that the young from Group I were definitely superior to those from Group II, thus indicating inferior milk production in Group II dams. There was no loss of young from any of the litters in Group I up to 8 weeks but in the other group 4 pigs were lost from 3 litters.

The level of protein intake. By two further feeding trials in which both individual and group feeding were used Woodman and Evans (Ref. 6) have extended and confirmed earlier findings reported in this Guide for 1942 that over the entire feeding period from 46-200 lb. liveweight there were no statistically significant differences between the results for pigs on the standard protein and low-protein diets, whether judged on the basis of the mean number of days required to reach 200 lb. liveweight, the mean daily rate of liveweight increase, or the mean lb. of meal consumed per lb. liveweight gain. In one trial the control ration contained 7 per cent. of white fishmeal to 150 lb. liveweight and then 10 per cent. of bean meal from 150 to 200 lb. liveweight; in a second ration the fish meal plus 11 per cent. of barley meal was replaced by 16 per cent. bean meal plus 2 per cent. blood meal to 150 lb. liveweight and thereafter only 5 per cent. of bean meal to 200 lb. liveweight, whilst the third ration was the same as the second up to 90 lb. live weight and thereafter no protein supplement. Whilst this and a further trial in which no protein supplement was given after 90 lb. liveweight showed that this omission of protein supplement caused the animals to be less thrifty over the period 90-150 lb. liveweight it is possible that a more satisfactory comparison with the control group might have been obtained if the protein supplement had been reduced gradually at 90 lb. and finally omitted at about 120 lb. liveweight, although the small differences were of minor practical importance and had no significant effect on the results over the whole period. It still remains to be seen whether these conclusions will hold good when animal protein is completely replaced by vegetable protein. Post-slaughter data indicate that if the low protein intake level is sufficient to support maximum growth no significant falling off in carcase quality or conformation need be feared.

Treatment of foodstuffs with yeast. In a monograph recently to hand from the Ukraine, it is reported that the following beneficial results were obtained by the addition of yeast to feeding stuffs in amounts equivalent to 1.25—2.50 per cent. of the dry matter of the ration. (1) With boars the volume of ejaculate and the number of spermatozoa increased. (2) With sows there was an increase in the size, weight and ante-natal development of the foetuses. (3) Nursing sows had an increase in milk yield as indicated by the development of the young at weaning. (4) Weaned stock, receiving the yeast supplement, showed as a rule greater average daily liveweight gains and consumed less food per lb. of liveweight increase than the controls. (5) Piglets so fed showed an improvement in health as indicated by lack of digestive disturbances and resistance to certain infections and deficiency diseases. The secretory activity of the salivary glands and the stomach was stimulated and, although there was no apparent increase in the digestibility co-efficients of the constituents of the ration, the rate of deposition of nitrogen in the experimental animals was increased. It is considered that the use of yeast treated foodstuffs should be encouraged to the largest possible extent on all pedigree and commercial pig farms.

POULTRY NUTRITION.

Iodinated protein. This material which has been extensively tested for use as a supplement for dairy cows (q.v.) has now been tried in the form of iodinated casein (protamone) as a supplement for laying hens (Ref. 7) with satisfactory results. The optimal amount was 1 oz. of the iodinated casein to 300 lb. of food and the trial was started with White Leghorn hens when they were in, or about to go into, moult. The use of the protamone appeared to hasten moult and growth of new feathers. Over a period of 12 months 12 control birds gave 933 eggs whereas 12 experimental birds gave 1,612 eggs. In each group two birds died. There was thus no effect on the mortality rate of the hens, nor was there any difference in the average weight of the eggs produced.

Effect of irradiation. Heywang (Ref. 8) reports experiments with growing chicks and laying pullets in which in each case, during the hot summer months, the birds were subjected to irradiation from a 40-watt lamp from midnight to daylight with a view to increasing their food intake. Growing chicks of either sex ate more food and made greater gains in liveweight over a period of 12 weeks than did control non-irradiated chicks. There was no extra benefit by extending the time of irradiation to cover the whole period of darkness. Similar trials with pullets, when egg production was low as a result of reduced food intake, gave no evidence of any appreciable effect on food consumption, egg production or liveweight. This applied equally whether the birds had been reared under the irradiation system or had not previously been irradiated.

Foodstuffs, various. Bolton and Hale (Ref. 9) have shown that either potato flakes or slices compare favourably with cereals, as regards their effects on egg production, when amounts up to 42.5 per cent. of either product were included in the mash of laying pullets.

Chewing's fescue seed of low germination capacity was found to be able to replace the 30 per cent. of oats in a mash for growing chicks without any deleterious results. Despite the bulkiness the ration was readily eaten and there was no significant difference in growth response between these and control birds. The fescue seed contained 12.8 per cent. crude protein, 11.6 per cent. crude fibre and 61.7 per cent. nitrogen-free extractives.

A Russian worker has calculated that fowls put out for 2—2½ months on stubble fields after the harvest may pick up during that period from 20-24 lb. of grain and growing chicks from 9—13 lb. and in addition the birds consume large numbers of insect pests as well as weed seeds. On one state farm the fowls on stubble produced more eggs and showed a greater gain of weight than control birds kept in runs.

Sheehy *et al* (Ref. 10) have drawn attention to the fact that if meat and bone meal is

included in the ration of chicks it should not exceed 13 per cent. of the ration, and attention should be paid to the make-up of the remainder of the diet. The ration must be made complete in respect to all the various essential food factors including riboflavin and other members of the vitamin B complex.

Six-day chick disease. Under certain conditions, whilst fertility and hatchability may have been good and the appearance of the chicks at hatching satisfactory, commencing on the sixth day heavy losses may occur and continue until the chicks are 12—14 days old, with a peak of mortality, which may amount to 30—50 per cent., on the 8th, 9th or 10th days. Temperton and Bythell (Ref. 11) consider that this trouble is due to a lack of available energy in the ration, owing to the inferior quality of starter rations due to a lack of whole grain and maize products and a deterioration in the quality of the nitrogen-free extractives of millers' offals and the inferior quality of other cereal products permitted for poultry feeding. They are of the opinion that the solvents used in the manufacture of palm kernel meal are not responsible for the onset of the disease, but that palm kernel meal is unpalatable and of low energy value and that its use in chick rations is inadvisable. Common *et al.* (Ref. 12) support these findings, but they also suggest that environment conditions such as might produce cooling effects and hence a relative deficiency of available energy may be a causal factor in precipitating the condition. Further confirmation comes from the thorough investigation conducted by Barton-Mann (Ref. 13) who concludes that the trouble is a disease of intestinal putrefaction which may be caused by any ration containing (*a*) insufficient starch or carbohydrate to maintain an acid reaction to the lower end of the intestine, (*b*) an excess of fibre or sponge-like fibre, *e.g.*, in palm kernel meal or sugar beet pulp which assists the proliferation of putrefactive bacteria, (*c*) animal proteins showing evidence of putrefaction, (*d*) residual oils which destroy vitamin A.

GENERAL.

Fodder cellulose. Scandinavian feeding trials have confirmed the earlier findings of Woodman (this Guide, 1944) as to the digestibility and feeding value of this material, when dried, provided adequate protein and mineral supplements are given. Cows would consume 5—10 lb. daily and horses 6—10 lb., the latter over long periods of hard work, with as little supplementary protein as 6 oz. of digestible protein.

Rye-grass seed. Common (Ref. 14) has extended his work on unusual foodstuffs and has shown that ground high-quality Northern Irish ryegrass seed had a chemical composition and digestibility comparable with that of oats. Ground rough perennial ryegrass seed had a starch equivalent equal to 90—95 per cent. of that of oats and the bulked cleanings from the same seeds starch equivalent equal to about 80 per cent. of that of oats. It is considered that some of the poorer quality fractions of the cleanings might be excluded from cleanings intended for use as feeding stuffs.

Grass drying and haymaking. Scandinavian workers report trials with two types of driers in which it was found that, under good conditions, 93 per cent. of the total nutrients and of the digestible protein were preserved in the case of pasture grass. With a clover crop recovery averaged 97 per cent. of the total nutrients and 89 per cent. of the digestible protein. In haymaking trials where the crop was put on to hurdles without wilting 84 per cent. of the total nutrients and of the digestible protein were retained, although losses were greater in bad weather. Drying in cocks gave average recoveries of 80 per cent. of total nutrients and 74 per cent. of digestible protein.

Sugar beet tops. Rayns (Ref. 15) has drawn attention to the value of this material as a feedingstuff. He points out that in 1944 in Britain there were 417,900 acres under sugar beet giving 8 tons per acre of tops, a yield equivalent to that from 250,000 acres of swedes. The tops, if allowed to wilt and stored in heaps, have the same feeding value as an

equal weight of swedes judging by feeding trials with sheep and cattle. Because of the oxalic acid in the tops which may render their lime unavailable, chalk should be fed with them. They contain 15 per cent. dry matter rich in protein and sugar. Mature sheep will eat 14—21 lb. of tops daily and a 10 cwt. bullock up to 100 lb. If they are to be fed to dairy cows the quantity should not exceed 42 lb. daily in order to avoid risk of taint in the milk.

W. GODDEN.

ROWETT RESEARCH INSTITUTE,
BUCKSBURN,
ABERDEENSHIRE.

References

1. BLAXTER, K. L. *Jour. Endocrinol* IV, pp. 237, 266.
2. LOOSLI, J. K., LUCAS, H. L. and MAYNARD, L. A. *Jour. Dairy Sci.*, XXVIII, p. 147.
3. THOMAS, W. J. *Jour. Min. Agric.* LII, p. 345.
4. HUNTER, A. H., EDEN, A. and GREEN, H. H. *Jour. Comp. Path. Therap.*, LV, pp. 19, 29.
5. FISHWICK, V. C. *Agric. Progr.* XX, p. 11.
6. WOODMAN, H. E. and EVANS, R. E. *Jour. Agric. Sci.* XXXV, p. 133.
7. TURNER, C. W., IRWIN, M. R. and REINEKE, E. P. *Poultry Sci.* XXIV, pp. 171, 522.
8. HEYWANG, B. W. *Poultry Sci.* XXIII, p. 481 ; XXIV, p. 83.
9. BOLTON, W. and HALE, R. W. *Jour. Agric. Sci.*, XXXV, p. 158.
10. SHEEHY, E. J., SENIOR, B. J. and BURKE, E. M. *Eire Dep. Agric. Jour.*, XLII, p. 194.
11. TEMPERTON, H. and BYTHELL, D. W. P. *Vet. Rec.*, LVI, p. 409.
12. COMMON, R. H., KERR, W. R. and LAMONT, H. G. *Vet. Rec.*, LVII, p. 45.
13. BARTON-MANN, T. *Jour. Agric. Sci.*, XXXV, pp. 95, 98, 101, 108.
14. COMMON, R. H. *Jour. Agric. Sci*,. XXXV, p. 56.
15. RAYNS, F. *Jour. Min. Agric.*, LII, p. 341.

FARM IMPLEMENTS AND MACHINERY

GENERAL FARM MECHANIZATION.

On several occasions over the last two years reference has been made in this section of the *Guide* to American statistics on machinery manufacture or utilization. These have been taken from U.S.D.A. Bulletins or from Annual Statistical reviews published by certain trade journals, and have been used mainly to illustrate general progress in farm mechanization. Sometimes, however, the same statistics have been used to support forecasts of the future trend of mechanization in this country—not in any real expectation that American events will repeat themselves here, but because, except for the results of an occasional census or two, there have been no British figures to start from. It is in these circumstances that the interim review of Agricultural Machinery requirements drawn up by the N.F.U. is particularly welcome (Ref. 1). Indeed, whether the figures themselves can be accepted without criticism or not—and manufacturers, to whom presumably they are particularly addressed, may very well find some of them optimistic—certain things concerning them should be given due recognition immediately. The review has been drawn up by farmers, and indicates both their firm belief that there must be even more mechanization in the future, and their deep concern lest the necessary machines should not be forthcoming. No criticism of figures can alter the genuineness or importance of these feelings, nor can any be put forward legitimately unless it is backed up both by better estimates and by evidence of their validity.

The review contains figures of three distinct kinds, and one criticism which may be legitimate in spite of what has been said above, is that they might with advantage have been kept separate. Some of the figures are official estimates, based on the 1944 Machinery Census or on returns of imports and manufactures, and are therefore beyond question. Incidentally these are of great value in themselves because over the last few years official information of the kind has not been at all readily accessible.

Certain other figures represent what may be called sound estimates in the sense that there is some clearly stated reasoning behind them ; but, in the absence of such reasoning, some others cannot be regarded as being better than guesses. Because all three are mixed in presentation, an undeserved shadow of doubt may be cast over the sounder estimates. For example no very serious objection can be taken to the final estimates of annual farm tractor requirements—1,500 tracklayers and 26,000-odd 3-or 4-wheeled machines—based, as they are, on definite statistics of numbers and sizes of holdings. But the corresponding figure of 14,500 2-wheeled tractors has behind it only the statement that " A provisional estimate of demand is 100,000 " with no indication of why 10,000 or a million might not have served equally well. Again, some of the figures for " replacements and additional requirements " may be open to doubt on rather different grounds. Thus, over the war years, the great majority of all the ploughs manufactured or imported have been of the everyday

rather light-weight type, and even farmers who would have greatly preferred something heavier or different have, for the most part, had to make do with whatever was readily available. At the moment all these farmers still want a plough in the sense that they have not yet got exactly what they originally intended to get, but this does not necessarily mean that they will all buy special ones when available unless they can trade in, or otherwise dispose of without undue loss, those they already have. It might therefore be argued that the total immediate demand for ploughs is not the number of special ploughs needed plus the number of ordinary ploughs needed, but some figure not greatly in excess of the demand for one or other type alone.

In its conclusion the N.F.U. review draws particular attention to what the machinery needs of British farmers may be worth to the general Engineering Industry. In the rather limited field covered by this report alone machinery needs represent a value of something over £20 million annually.

Two other publications offer pictures of agriculture as seen through ordinary engineering eyes. The first of these is the very competent review published annually under the general title of " Engineering Outlook " by one of our leading engineering journals (Ref. 2). This gives more facts and figures than are ordinarily to be found in articles of this kind—although some of the figures are not in very understandable form. Statistics about tractors and ploughs, for example, look rather meaningless when they are expressed in tons. It should be recognised, however, that the fact that they are expressed in this unhandy form is in no way the fault of the journal concerned. The other publication (Ref. 3) is a report sponsored by the Engineering Industries Association which attempts to weigh up the new commercial prospects which agriculture may offer to engineering firms not at present engaged in this particular field. One cannot do better here than to quote, without comment, what appears to be the main conclusion : " In our view entry into the agricultural market by an engineering manufacturer not hitherto experienced in this field would be at best a speculative enterprise ; and would almost certainly prove disastrous unless he had ample capital to employ the most experienced designers and technicians, opportunity to carry out the most careful experimentation, and financial resources strong enough to enable him to wait for a long profit."

In all the foregoing there has been implied the need for more exact and more regularly-produced statistics. The latter qualification is important because as backing for what is, in effect, Consumer Research, the results of a spot estimate, however accurate, are much less effective than graphs which show trends from one year to another.

One such graph appears in the 1946 issue of one of the statistical reviews already mentioned (Ref. 4). It shows the gradual increase over the last 35 years in the U.S. farm tractor population, with the corresponding decline in total numbers of farm horses and mules. The peak of the horse and mule curve occurred round about 1918, *i.e.*, at the end of the first World War, although it is by no means certain that the war itself had much to do with it. Since then both the declining horse curve and the rising tractor curve have been quite remarkably steady ; there was a temporary flattening of the tractor curve in the early thirties but it very quickly returned to normal.

What is really remarkable is that if a prospective manufacturer, or anyone with a similar interest, had used the graph up to, say, 1938 as a basis for estimating the 1945 total, he would almost certainly have been within 10 per cent. of the actual figure although the second World War has happened meanwhile. A rough idea of what has happened over the last quarter of a century is given by the fact that while in 1920 there were roughly 100 horses or mules for every tractor in American farming, the corresponding figure to-day is only about 6. In this particular publication—and there are others like it—there can be found every year all the information necessary for plotting graphs of the kind described for each and every farm implement of any consequence. One cannot help feeling that if corresponding

information were available here, the general difficulty of getting the machines we want would be very materially reduced.

Another very interesting table included in the same journal—but based on a publication of the U.S.D.A. Bureau of Agricultural Economics to which no exact reference is available—shows the average prices which American farmers paid for different types of machine in each of the last six years. The general price increases over the period strike one as being remarkably modest in all the circumstances ; whilst the current prices will no doubt make our farmers feel badly off. The prices tabulated below in illustration have been converted to sterling at $4 to the £.

Average prices paid by American Farmers for some typical machines.

	1939	1945
12-spout grain drill	£42	£47
7-ft. binder	£64	£73
8-ft. p.t.o. combine	£262	£275
1-row elevator potato digger	£42	£48
2-furrow tractor plough...	£31	£34

As a final example of the kind of information that is to be had from the same source there may be mentioned some figures relating to exports.

The total value of all the American farm machinery (including tractors) exported in 1930 represented just under 20 per cent. of the total value of all that was manufactured ; for 1935 and 1940 the corresponding figures were about $7\frac{1}{2}$ per cent. and $13\frac{1}{2}$ per cent. respectively. Bearing in mind that a considerable proportion of these exports would almost certainly go to areas close at hand, like Canada and South America, the fraction represented by the most Britain has ever imported in any year cannot be a very impressive one from the standpoint of the American trade as a whole. And from this there is a quite important moral to be drawn in connexion with the general problem of meeting future machinery needs. There is not the slightest reason to expect that American manufacturers will re-design any of their machines—or make any but quite minor modifications to them—just to meet the special requirements or conditions of British farming. Nevertheless, when they could get them, our farmers managed reasonably well with American tractors, American drills and even American combines. But from now on it is not so much on machines like these as on things like root harvesters and on appliances for the small—and even very small—farms that the further extension of farm mechanization will depend. With these, the peculiarities of British soils, crops and farms will have to be taken more and more into account—so much so that there is very little hope that American designed machines can ever offer a satisfactory solution. It is for this fundamental reason, rather than on account of currency or other restrictions, that we need to put our own manufacturing industry on its feet again.

Some rather more definite clues than are ordinarily available to the differences between our own and American farming are to be found in the report of a Machinery delegation, which spent several months in the U.S.A. last year (Ref. 5). Among the opinions recorded is that the main reasons why ' mixed ' farming in the Middle West and in Eastern Canada is carried on with much less labour than would be needed on nominally similar holdings in Britain are not, as has sometimes been suggested, to be found in a greater use of labour-saving appliances in or around the yard. They are to be found rather in more favourable circumstances : more compact farms ; lighter and more friable soils ; less need for cultivating or harvesting under wet conditions ; easier weed control ; less diversity of cropping ; and a much looser association between livestock and arable farming.

One section of the report is concerned with the general way in which agricultural machinery development is carried on in the States, and with the reasons behind its quite

evident success. Here again much of the answer seems to lie in different and more favourable conditions—in this case of an economic rather than an agricultural nature. But there were other causes as well, of which two may be mentioned here. One was the broader outlook on mechanization arising from a general urge to cut down the man-hours involved in production, quite regardless of the nature of the product or of the circumstances in which it is produced. A direct consequence of this is a unity of purpose quite beyond anything yet experienced in this country: farmers, manufacturers and scientists all appreciating what the others are trying to do. Again, the report emphasizes the great part played as regards both machinery development and the general extensions of farm mechanization (which are not by any means the same thing) by the " Consumer Relations " or " Product Research " organizations which all the larger American firms possess. The report also gives a good deal of information about recent advances in mechanization with particular regard to hay and silage making.

A separate article on farm machinery trends in the U.S.A. is also based mainly on material collected by the delegation just mentioned (Ref. 6). One general point with which it deals is the American insistence on " one-man " machines ; another is the comparative freedom from fixed traditions which brings about a general willingness to lower standards in the interests of mechanization. By way of complete contrast there may be mentioned an account of farm machinery in Germany and Denmark (Ref. 7).

Recent machinery developments—this time almost exclusively from the British aspect —are the subject of yet another paper which may be of interest to readers who are in search of descriptive rather than detailed information (Ref. 8). This also describes the general way in which some of the developmental work in this country is being carried on. Finally there may be mentioned a paper dealing with what is called the next phase in agricultural mechanization : the equipment of the small everyday non-specialized farm (Ref. 9). One of the fundamental difficulties here is that of producing an efficient combination of tractor and horses.

In general some horses have to be retained because of the ever-present problem of internal transport. On each of five smallish mixed farms for which fully detailed records were kept, there was not a week last year in which the hours put in by the farm cart did not exceed those put in by all the other implements combined. There is also the difficulty that modern machines tend to be too complicated and expensive for the small farm. Much could be accomplished by directing developmental effort more towards less-specialized if less " complete " equipment, but this would still leave the small farmer relatively at a disadvantage. The only other solution lies in the use of one machine on more than one farm—in theory by co-operation ; in practice by continuing something on the lines of the machinery services provided by County War Committees.

It should perhaps be emphasized that, from the farmer's standpoint, all these papers on trends and recent developments deal rather with the future : with the equipment and methods which may one day increase the general scope of farm mechanization. In the meantime—as the N.F.U. review implies—there is the more immediate problem of providing, from home rather than overseas sources, an adequate flow of more ordinary implements : those which most farmers are accustomed to use already ; and those which have already been accepted by enough farmers to make it certain that they will be needed in increasing numbers over the next year or two. It is with the latter that a recent report issued under the auspices of the Agricultural Machinery Development Board is mainly concerned (Ref. 10). It aims at giving, for the benefit of both existing manufacturers and potential newcomers to the industry, an idea of the types of equipment that will be most needed, and of some of the ' user requirements ' that designers should have in mind. It is, of course, one thing to provide machines which will do specific jobs efficiently ; and quite another to

provide machines which will fit economically into the everyday farming scheme. In the latter connexion a note on machinery capitalization may be of interest (Ref. 11).

TRACTORS.

In several of the contributions noticed in the preceding section, the key to the situation seems to lie in tractors somewhat different from those which have been readily available over the last few years.

One instance is the tracklayer, another is what is called the row-crop tractor ; and both have been much in mind lately because they have been difficult to obtain. On the other hand more than one discussion has led to the conclusion that even when these and other comparable types are freely available, there will still be unsolved power-unit problems particularly in connexion with small farm mechanization. In papers already discussed the writer has argued the need for something which at present is quite undefined and which can only be referred to as a ' missing link ' between the horse and the present day tractor. The main function of such an outfit would be not so much to attain a set performance in any particular operation as to fit into and round off the whole system. It can in the long run, therefore, only be defined by weighing up practically everything that happens on the every-day farm so as to bring to light the gaps and difficulties to which ordinary tractors offer no satisfactory solution. Two short notes, one on farm carting and one on tractor duty (Refs. 12 and 13), are of interest in this connexion : they provide no answers to specific questions, but give information of the kind that is needed. Another contribution on tractor costs and performance is more specific, and gives a lot of detailed information—all directly based on practical farm records—about working costs both overall and for particular operations (Ref. 14).

On the more technical side attention should certainly be given to a series of three articles weighing up present tractor design (Ref. 15). The first deals with the engine ; the second with the transmission ; and the third with what can only be called the ' chassis ' although, to be accurate, most tractors have no ' chassis.' These articles deal mainly with constructional points, and are obviously intended more for engineers than for farmers. They are, however, fairly simply written and are very well illustrated ; so that mechanically-minded farmers who want something a little more advanced than the usual ' how-your-tractor-works ' material, would find them worth reading.

Two American research reports on the use of liquid in tractor tyres have come to hand during the year under review (Ref. 16). One conclusion from the work was that if the final inflation pressure and back-axle weight remained the same the percentage of liquid fill itself had no significant effect on the traction capacity of the tractor.

In these particular tests both the final inflation pressure and the tyre cross section seemed to have more effect on adhesion than has been experienced in similar tests in this country. The second report is mainly concerned with the effect of liquid filling on vibration and on bouncing characteristics. When the tyres were completely filled with liquid there was generally a marked increase in both the magnitude and number of the shocks resulting from vertical accelerations of the axle. Putting more liquid in the tyres decreased the period of vibration of the axle but increased the rate at which vibrations were damped out. The overall vibrations effect in any particular case, from the point of view of the tractor driver for example, would therefore seem to depend too much on other factors to be predicted from considerations of tyres alone. As regards bounce, the conclusions seemed to be exactly opposite according to whether the tractor was crossing a ridge or a depression. In the former case the maximum vertical motion of the axle was increased, and in the latter it was decreased, by increasing the extent of liquid fill. Those to whom American bulletins are not easily available may like to know of a British summary of this work (Ref. 17).

As a final hint of things to come in the tractor sphere mention may be made of a "Driverless" tractor that has been in operation in Texas (Ref. 18). The tractor is a standard three-wheeled model fitted with a self-steering attachment controlled by discs which run in the open furrow. If it is doing work in rows or lands a man is necessary for turning it round at the ends; but one man (with a truck) can keep three or four outfits in action simultaneously. If on the other hand it is working round and round, it can be left to itself except for re-fuelling. Quite spectacular reductions of both capital and running costs are said to follow its introduction.

CULTIVATIONS.

Among the papers to be considered under this heading are two or three which are concerned directly or indirectly with Rotary Tillage. Contributions of this kind are always difficult to discuss fairly because there is inevitably in the back of one's mind an overriding question to which the papers themselves give no hint of an answer.

It is roughly: why, in spite of a hundred years of almost continuous inventive effort, has rotary tillage—or for that matter any direct application of mechanical power to the soil—had no appreciable impact on everyday farming? If the contribution concerns some particular new appliance, and is written by an enthusiast, it may very well suggest that this time the result will be different because the essential working principle of the appliance in question is different. In fact, however, a little delving among the records generally shows that precisely the same principle was applied in some forgotten machine of the last century. The truth is, probably, that all these new "principles" are concerned with axes of rotations and things of that sort instead of with the soil itself and what, from the standpoint of the plant, needs to be done to it. Indeed engineers can hardly be expected to produce new and more effective cultivating appliances until some one has told them more exactly what the appliance will have to do. With this in mind, it is refreshing to turn to a recent article by Sanders which should be read by everyone who is engaged in, or thinking of engaging in, the invention of new tillage appliances (Ref. 19). It gives no exact information—of the kind which an engineer can copy into his pocket book and use in designing machines—but it does give a very vivid picture of what cultivation is all about, and why, for example, chopping soil up is by no means the same as making a tilth. In another article Rogers covers something of the same ground from a rather different point of view (Ref. 20). Among the particular subjects discussed are soil moisture, root depth, and soil organic matter. Rogers mentions that he has traced roots to $2\frac{1}{2}$ feet deep and lucerne roots to 5 feet. Indeed it would appear that plant roots are liable to go just about as deep as some limiting factor like a hard pan, or natural rock, or the water table will allow. One wonders, whether—beyond, say, the first 18 or 20 inches—this deep penetration is due to mere inquisitiveness or whether it serves some useful purpose.

As it happens all the rotary tillage papers on this occasion come from America where, because of efforts to counter soil erosion, cultivation methods are definitely tending to change. The first, by Kelsey, deals with the spring-tine type of rotary tiller which originated in a Swiss invention of 1910 (Ref. 21).

Rotary tillers of this kind were imported in considerable numbers between the wars and from these have descended all the many small models now manufactured here for horticultural use. In America, however, rotary tillers of this spring-tine type are made in a much wider range of sizes up to one with a 110 h.p. engine. The paper describes the different forms of tine that have been evolved for various special conditions partly as the result of research work at the Iowa Experiment Station. It would certainly appear is if, on the engineering side at any rate, there is more design on the basis of more or less exact knowledge behind this machine than has usually been the case. Moreover, on the agri-

cultural side, and in the interests of erosion control, American thought at the moment is mainly concerned with such things as the chopping up and distribution of trash which are much more tangible than tilths and crumb structures. A companion paper deals with particular rotary tillage applications including, for example, the control of white grubs in U.S. Forest Service nurseries, and the handling of compost heaps on the grand scale (Ref. 22). Yet another paper is mainly of historical interest, and British readers, if they are not familiar with it already, will find most of its material more readily accessible from other sources (Ref. 23). It does, however, describe several early American machines and some current ones of which the writer, at any rate, had not previously heard.

Among the new, but not in any sense revolutionary, cultivating implements that have come into fairly wide use in America over the last decade, is the so-called Weeder Mulcher. This is only one of a number of implements which are all very similar and have the same purpose. The broad idea is that of very light flexible close-set tines which are pulled at high speed over growing crops when they are just beyond the seedling stage, as a cheap means of weed control. Preliminary trials carried out at the N.I.A.E. have been reported (Ref. 24). Broadly speaking the implement was ineffective because, although counts immediately before and after treatment showed that a considerable proportion of the weeds present had been disturbed, subsequent counts showed that they had not suffered much in the process. In the more friable soils, and with the greater certainty of periods of hot dry weather, that exist in the areas from which the Weeder Mulcher comes, the result might very well be different.

HAY AND SILAGE MACHINERY.

In the report on farm mechanization in America already quoted (Ref. 5) particular attention was drawn to the importance of silage. In the Mid-Western and North-Eastern regions at least—as well as in Eastern Canada—every farm had its appropriate complement of tower silos. Farmers in those regions were favoured both by having labour-saving machines in closer prospect, and by having maize as their main, and in some areas almost universal, silage crop. A more vigorous attempt to find maize hybrids suitable for the same purpose in this country was strongly recommended. Nevertheless, as a member of the delegation concerned, the writer recalls being told over and over again, by farmers and experimenters alike, that few American farmers would bother with silage if they could be sure of getting their hay in good condition. And, so far as experimental work in agricultural engineering is concerned, it is certainly hay rather than silage that is in the limelight at present. The new cutter-chopper-blowers, which we in this country regard almost exclusively as silage combines, figure very prominently in the production plans of the larger manufacturers, but whether they will be used mainly for silage or for hay remains to be seen. In the meantime, Street has argued forcibly that British farmers at any rate ought to make both hay and silage—from the same field if necessary—as a regular practice (Ref. 25). He is thinking particularly of relatively small-scale milk producers, and of silage making as being done an hour or two at a time in between milkings. Considered in this way, silage making demands no equipment that is not to be found already on the farm except for the silo itself ; and even that can be dispensed with by using pits or stacks. In fact, the main requirement is not machinery but determination and willingness to sweat. Reference may also be made to an account of observations made during 1945 of six different systems of silage mechanization (Ref. 26). Perhaps it is an exaggeration to call these "systems" because no one of them had been at all carefully worked out. They were rather the methods being practised in that year by six different farmers, all keen on silage mechanization, but, all, almost certainly, having to manage with what was, to some extent, a compromise between the equipment they would have liked and what they could get. One broad conclusion

was parallel with Street's ideas on the subject; that on small farms at any rate a good deal could be accomplished by proper use of existing equipment.

To return to America—only because it is from there that much of the new equipment has originated—some attention was given in last year's *Guide* to the general conflict of ideas that has arisen; to some of the reasons behind it; and, in particular, to the emergence of a sudden and almost unreasoning enthusiasm for mow drying. This enthusiasm continues—so much so that the flow of papers on the research and experimental aspects of the subject has become almost embarrassing. In the first place mention should be made of a very comprehensive U.S.D.A. research programme which aims at comparing three methods of harvesting and preserving forage crops: silage making. haymaking in the field, and haymaking by curing in the barn. This covers a very wide range of experimental data up to and including feeding trials and will continue, in the first instance, for 3 years. A preliminary report on the first year's work has been published (Ref. 27) and includes tabulated figures for the man-and machine-hours needed for each method both per acre harvested and per ton of dry matter stored. It is interesting to note that on the latter basis there were no appreciable differences in the three methods: using, so far as one can make out, ordinary rather than up-to-the-minute equipment in each case. Coming now to mow drying, a very comprehensive bulletin on the design, installation, and operation of the barn hay drier has been issued under the auspices of the Tennessee Valley Authority (Ref. 28). It includes a very useful list of published papers up to about 1943; but it is not very up to date as regards practical experiences. Several papers seem to suggest that the method is not as straightforward as some of the earlier enthusiasts claimed. Frudden (Ref. 29) discusses rate of moisture removal and, on the basis of experiments by Jennings at Cornell during 1944 and 1945, recommends that all mow drying should be carried out so as to reduce moisture content to 10 per cent. within 7 days. Unfortunately the more carefully controlled experiments are, the less they take account of two of the major bugbears in practice: uneven packing of the crop and air losses at the boundary of the mass. The effectivenesss of the drying obviously depends on the volume of drying air passing through the crop: but of the air blown into the system not by any means all goes through the crop; while not all the hay gets equal benefit from what does go through.

Duffee, who was possibly the originator of hay chopping, now seems doubtful of the wisdom of chopping as a preliminary to mow drying (Ref. 30). Examination of a number of installations during ordinary farm operation disclosed quite surprising vagaries in the air flow. These seemed to be due mainly to what were, in effect, blockages at the air exits from the ducting. The ducting system followed the design arrived at in the T.V.A. experiments which were all carried out with long hay. But whereas long hay more or less naturally drapes itself over the duct exits in such away as not to prevent the free outflow of air, chopped hay tends to fall straight down and plug the vent. Quite clearly some further study of duct design is needed: in the meantime farmers are recommended not to buy forage harvesters unless an average length of chop of not less than 4 inches can be guaranteed. Incidentally a longer chop is strongly to be recommended from the feeding standpoint—indeed, those who are concerned solely with the feeding end do not seem to like chopped hay at all. The need for further studies of the technicalities of air flow—whether for chopped hay or not—seems to be widely recognised and references to several papers on the subject may be given (Refs. 31 to 34). For the most part, however, these record what happened on a particular occasion with a particular drier, and give very little guidance as to what would have happened with a different crop and a different arrangement of ducting. One general result established by several researches is that if, for the flow of air through hay, the relation between velocity and static pressure is expressed in the form $V = \text{constant} \times P^n$,

the value of the exponent is not 0.5 (as it would be in the case of a plain orifice or duct) but somewhere between 0.65 and 0.75.

Rather apart from all this is a paper on artificial drying in the stack which takes as its starting point the work on the same subject which was carried out here about twenty years ago (Ref. 35). The stacks were of a size to contain about 10 tons of finished hay and were covered over the top and upper sides with a fibre-glass tarpaulin. In a test with alfalfa the moisture content was reduced from about 37 per cent. to 16 per cent. by 90 hours of blowing over a total period of 7 days. To drive the fan needed 9½ gallons of petrol. In another test with soyabean hay the moisture content was reduced from 38 to 12 per cent. by 124 hours of blowing over 11 days.

The hay seems to have been quite satisfactory but no indication of the overall labour requirement and general practicability from the farm standpoint is given.

The idea of 'assisted' curing with cold or only slightly heated air is also being applied to baled hay. A paper by Miller describes a very elaborate set up devised by a Pennsylvania farmer for this purpose (Ref. 36). All the difficulties over air losses mentioned earlier apply even more forcibly when bales are to be dried and for this reason it is necessary to provide engine, fan and ducting capable of delivering three or four times as much air as would be necessary for mow-drying loose hay. The power costs of drying were estimated at about $3 per ton. One would expect the weak point of this system to lie in the costs of handling the bales from field to drier and from drier to final storage; but no information on this is given.

As a final example of the lengths to which American farmers or experimenters are going in their efforts to arrive at weather-proof-haymaking there may be mentioned a paper by Anderson which describes a farmer's own trials and experiences over 7 years (Ref. 37). In one of his schemes—tried on a considerable scale in 1945—the hay was dried in the load and kept in the load until fed or sold. Special racks on which the hay could be loaded around a central metal spout were used. In the field these were carried on specially designed 2-wheel trailers while at the drier end the whole rack could be lifted off with its load still intact. Each load consisted of about 5 tons of partially cured hay. The drier consisted of fan, furnace and ducting so arranged that the hot air was blown up at floor level through a grating large enough to take 6 loads side by side. After drying—or, to be accurate, finishing-off—which was generally accomplished overnight, the loads were taken either to something on the lines of a Dutch barn or to be sheeted over in the field. This particular farmer sets down what is to be aimed at as the production of hay of maximum feeding value, the cost from field to cow to be as low as possible. In his view none of the existing barn curing systems—nor his own drying-in-the-load idea—meets these requirements.

An account of hay baling on a West Yorkshire farm, with details of times and costs, has been published (Ref. 38). The baler was a small one of the 'slicing' type without automatic tying. In 131 hours, of which for various reasons over 40 were spent idle in the field, 84 acres of hay of three kinds were baled. On meadow hay, using the same machine in both cases, pick-up baling from an even swath was more than twice as fast as stationary baling from cocks. A straightforward cost comparison between orthodox haymaking and pick-up baling came out well in favour of the former which used slightly less labour and saved a tractor. No account was taken, however, of the greater convenience of having the hay in bales; nor, on the other hand, was any allowance made for depreciation of the baler. Baling was also the riskier method in uncertain weather because of its slower throughput at the critical time, but this conclusion in particular—and perhaps the results of the whole comparison—might be quite different with a self-tying baler.

GRAIN HARVESTING, DRYING AND STORAGE.

The discussion at an N.F.U. conference on harvesting by combine showed that, if there is general agreement about the advantages of the method, there are widely varying opinions both as to the kind of machine that is wanted and the way in which it should be used (Ref. 39). In the main paper Cashmore dealt chiefly with points arising from observations during the 1945 season including grain losses, the special care necessary with malting barley, windrowing, and the harvesting of small grass seeds. Amplifying and explaining the N.I.A.E. work on grain losses mentioned in last year's *Guide*, he pointed out that in any particular crop there is a critical speed of travel above which losses are liable to mount rapidly, and that this speed tends to fall as the weight of straw taken increases. Cutter bar losses, however, often make up a high proportion of the total; and these tend to rise as the speed increases independently of other considerations. Weedy crops greatly increase losses and in one crop on which accurate measurements were taken the normal sieve loss of 13 lb. per acre rose to 290 lb. per acre in a bad patch of thistles.

All kinds of grass seeds have been combined successfully but close attention to detail and careful adjustment are essential. Cocksfoot is one of the most difficult, and a choice has nearly always to be made between starting early with the result that immature seeds are left in the straw and starting late with a greatly increased risk of excessive shattering. Two main topics for argument at the N.F.U. Conference were the size of the combine and the relative advantages of auger and canvas. Opinions from the large field arable areas naturally favoured wide, relatively slow-moving machines while those from mixed farming areas equally naturally favoured narrow machines handy in lanes and gateways. In much the same way the Southern areas seemed to prefer a canvas to an auger while those from the North took the opposite view. Obviously there can be no "always right" answer to any question of this sort although, as a manufacturer pointed out, something nearer unanimity of opinion will be essential if British-made combines are ever to be available at reasonable prices. Among the other subjects dealt with was windrowing for which a number of advantages such as an earlier start, reduced losses, and a more mellow sample of barley were claimed. A brief account of 1945 experiences on the farm of one of the speakers concerned has been given in another publication (Ref. 40). One contribution to the N.F.U. discussion which deserves special notice was a very clear account by Bishop of the chemical and biological aspects of grain drying. He dealt in particular with the formation of moulds, dormancy in germination, and the phenomenon known as "case-hardening" and drew conclusions about the essentials of drying equipment. As might be expected he was in favour of thermostatic control, mixing during drying, and plants capable of taking out anything up to 15 per cent. of moisture without too much hurry. In a paper covering both the combine and the binder Chartres (Ref. 41) makes—on the basis of his own farm experience—some interesting cost comparisons with the results from Cambridge which were published two years ago. The man-hours per acre required for harvesting with binders in each of three different seasons were much higher than those given in the Cambridge report with the result that combines showed to even greater relative advantage. This paper was read in Edinburgh and was written with special reference to Scottish conditions.

Two different special ways of dealing with oats had been tried. In one the oats were bound and stooked for about 10 days. Then the sheaves were laid down, the bands cut and the crop picked up and threshed with a combine followed by a pick-up straw baler. In this method weather risks were materially reduced and the straw recovered in good condition; but there was no saving of man-hours in comparison with orthodox harvesting. The second method consisted virtually of windrowing after cutting by binder with trip mechanism and twine removed. This was an ideal method given spells of fine days but failed badly in the constant rain of 1944. An account of 1944 experiences with combine

harvesters in S.E. Scotland, also indicates that they are not so ideal for oats as they may be for other crops (Ref. 42). The penetration of combines northwards started so recently that it is surprising to find that over 120 of them worked on the eastern side of Scotland alone. In what was a particularly difficult season the machines performed well enough to convince the writers of the account that combining had come to S.E. Scotland to stay. They are, however, careful to point out that (in that particular year) combining was not a cheap method of harvesting.

A comprehensive bulletin on bin ventilation based on experiments at the N.I.A.E. and elsewhere has been published very recently (Ref. 43). In general, bin ventilation may aim at either or both of two objects: to keep moist grain cool during bulk storage so that growth of mould and the development of mustiness are prevented or delayed; or to dry the grain. The experiments showed that ventilation with unheated air, even with a very low airflow, was quite effective either in preventing heating in grain with a moisture content of 20-22 per cent., or in cooling grain that had already heated. The ventilation only dried the grain to about 19 per cent.—the ‘equilibrium moisture content’ for air of 85 per cent. relative humidity. Moreover, ventilation only delayed the development of mustiness: in two of the experimental bins mustiness developed after 30 days and in another after 40 days, while in three instances damage to germination was noted after similar periods of storage. On the other hand when the ventilated air was slightly heated so that its relative humidity was reduced to 50 per cent. or so, bulked grain 8½ ft. deep and initially at a moisture content of 24 per cent. was dried to 14 per cent. in 17 days.

Drying however takes place from the bottom upwards so that the upper layers not only dry last but are subject to a stream of warm moist air right up to the final stage. Further experiments are needed to show how long grain can suffer these conditions without damage and, therefore, how great a depth can be heated safely in this fashion. Quite apart from the actual experimental results this bulletin gives clear explanations of all the complicated transfers of heat and moisture which take place and is well worth reading on this account alone.

In this country the general idea of bin ventilation developed out of the use of pneumatic elevation as a means of getting grain almost anywhere without appreciable expenditure of labour. An account of N.I.A.E. experimental work on this subject also gives information on sizes and design useful to those intending to instal such equipment (Ref. 44).

In spite of all that combines have accomplished, and of the great wartime increase in their numbers, the great bulk of British-grown grain is still dependent on the stationary thresher. A good few American machines have been imported to help out the work, and there have been many arguments as to their relative efficiency in comparison with those of our own manufacture. Some positive information on this question is given in a recent report from Cambridge (Ref. 45). The American machines had drums of the peg-type, a good deal narrower than the beater drums on the British ones, but gave at least as high throughput. Moreover, because of their labour-saving attachments such as the conveyor feeder, band cutter and straw and chaff blowers they needed fewer men. The straw and chaff blowers, however, were not an unmixed blessing. Cost comparisons between the two types of machine (where both were farmer-owned) came out strongly in favour of the American type. With wheat, for example, the cost was 4s. 11d. per quarter in the one case and only 2s. 8d. in the other. A number of suggestions for improving the British machines, both to reduce labour requirements and to lower overall costs, were made as a result of the study.

ROOT CROP MECHANIZATION.

Another report on trials of segmented beet seed has been received from Michigan (Ref. 46). This is one of the states in which beet is grown under non-irrigated conditions,

and in which particular interest is being taken in seed developments. It is here, for example, that " pelleted " beet seed is being produced commercially. In the pelleting process the seed is segmented and the segments coated with a material—of unknown composition but said to contain both fertilizers and fungicides—so as to form ' pills ' of uniform size and shape. The process is being applied to a range of other seeds as well.

The value of the Michigan trials was reduced by the fact that following a most unfavourable germinating and growing season the yields were only around the 5 tons per acre mark, *i.e.*, about half the normal for the land concerned. Subject to this, the results were definitely in favour of segmented seed. In comparison with normal seed : plant stands were nearly as high and yields were slightly higher ; while the overall singling labour required was significantly less by about 30 per cent. It was noted that the drill used was far from perfect ; and the distribution of segmented seed in the drill-rows far from uniform. In view of the abnormally low yields conclusions as to seed-rates are hardly worth reporting here. Widespread trials of segmented seed are being carried out in this country with, so far as one can make out, rather mixed results. One broad result is that while general opinions at singling time are very often pessimistic about segmented seed, they tend to grow more optimistic as the season advances. Segmented seed is certainly more ' touchy ' about germinating conditions, and on land liable to cap gives the impression that the relatively few viable seed germs sown have hardly enough combined energy to push their shoots through the crust. However, the resulting plant, or yield, is satisfactory, and there is no doubt about the reduction in singling labour that follows the use of segmented seed.

General progress in root harvesting has been reviewed in a paper by West and the present writer (Ref. 47). With potatoes the most important accomplishments in labour-saving so far have come from relatively simple developments like the wider use of elevator diggers or, where these are not practicable, from the use of power-driven spinners. One recent improvement—a deflector attachment for elevator diggers which both places the potatoes in more compact rows and enables the digger to work continuously—has been described in more detail elsewhere (Ref. 48). Modifications of this kind aim simply at getting the potatoes out more cleanly and placing them more compactly, leaving them to be picked up by hand as before. Various complete harvesters which aim finally at putting the potatoes into the cart are, however, in process of development. The one virtue of the potato spinner —whatever its imperfections in other directions—is that it gives much the same general level of performance in all types and conditions of soil. By contrast, elevator diggers— and all the complete harvesters which use elevator chain as the main separating mechanism—are less versatile : they are too vulnerable on sharp or stony soil, and too liable to blockage on wet or heavy soils. On the other hand, the various rotary appliances that are being tried experimentally all need the trash to be removed or disposed of in advance ; and this problem needs, and is receiving, independent study.

Developmental work on the harvesting of genuine root crops has so far been confined mainly to sugar beet because of the outstanding importance of this crop over the last few years. But, as West and the writer point out, advances in sugar beet harvesting are likely to be followed fairly quickly by corresponding developments with other farm root crops. The work in progress at the N.I.A.E. on this problem has been described in some detail (Ref. 49). Following critical trials of all available beet harvesters a good deal of intensive experimentation with components has been going on. As one step in the process, what may be called a ' hybrid ' prototype was built for trial last year. Finally, a real prototype embodying all the experience so far gained but no longer in any way a hybrid, is now nearing completion. In particular, this aims at putting both tops and beet into separate windrows, for mechanical loading if necessary, without in any way lowering the general standards of work expected from experienced hand workers. Whether this particular

machine comes to anything remains, of course, to be seen; but there is no doubt that the work in progress on these lines—whether at the N.I.A.E. or elsewhere—will prove fruitful in the not too distant future.

A number of American beet harvesters have been tried—with rather limited success—in this country, and an account of what they have accomplished in the conditions for which they were developed is therefore of interest (Ref. 50). This is written by an American expert who spent some months over here last year. In some areas much more progress than we have so far accomplished has been made, in the sense that a far greater proportion of the crop is now being harvested mechanically. As a supplementary note points out, however, practically the whole of the area concerned is irrigated and the resulting conditions are quite different from ours. Mechanization has also involved a lowering of standards, particularly as regards topping, quite beyond anything our growers or factories would be likely to tolerate.

MISCELLANEOUS.

If at any time prior to 1939, grass drying had 'settled down' into a farm process capable of fairly general application it would have been of incalculable benefit to British Agriculture both during the war and at the present time. In fact, it had not settled down in this way and consideration of the outstanding problems on which more general application would depend had to be deferred for the time being. It is solely for this reason, and not because of any doubt as to whether grass drying is worth going on with, that the subject is relegated to the miscellaneous section of this article. There are only two papers to be dealt with: an N.F.U. Bulletin on the process as at present carried on in Sweden; and what may be called a preliminary re-opening of the subject at an N.F.U. conference in this country (Refs. 51 and 52). The Swedish account deals almost exclusively with the overall economics of grass drying and gives little or no information about the design of the equipment concerned or the way it is used in practice. Nor does the bulletin itself give any clue to its origin; for example, whether it is simply a translation of something first published in Sweden or whether it was specially written for the occasion. The main theme of the other paper is the potential importance of grass drying and the need for tidying up the equipment which it involves. Broadly there are three more or less distinct things to be tidied up: the grass drying appliance itself; the picking-up and transport equipment which keeps it going; and the system in which the two fit together.

Up to now grass driers have fallen between two stools: the ideal of a cheap portable everyman outfit on the one hand; and something more suitable to factory than farm on the other. In either case there are quite inexorable thermodynamic relations between pounds of moisture removed and pounds of fuel burned to be reckoned with. None of the inventors in the small portable field of thought has yet reckoned with these successfully. The large plant on the other hand has not yet proved fully compatible in practice with the very different rates at which grass grows at different times during the nominal drying season. As a result users who started out with the intention of producing dried young grass have sometimes been satisfied with so-called "super hay," and from this uncertainty as to what material was in question has come much of the difficulty over the evolution of satisfactory equipment for loading and transporting. Enough has been done already to show that grass drying is not just a wild idea, but real practical success is unlikely to come without more and better research and experimental effort than has yet been applied.

As it happens crop drying also figures prominently in the only electrical contribution that calls for notice this year. This is a further report by Cameron Brown which deals with the possibilities of Electrification in Highland Agriculture (Ref. 53). None of its material is new, nor is any of it very specially concerned with the particular area in question. The report, however, provides a very useful summary of potential applications, in which, for those interested, each item is related to the Highland background.

S. J. WRIGHT.

References

1. "Interim Review of Agricultural Machinery Requirements." *National Farmers' Union.* Dec. 1945.
2. "The Engineering Outlook VIII–Agricultural Machinery." *Engineering.* Feb. 22, 1946.
3. "Engineering and Agriculture." *Engineering Industries Association.* Oct. 1945.
4. "Facts and Figures 1946." *Farm Implement News.* July 4, 1946.
5. "Farm Machinery in N. America." *Agriculture Overseas Report No. 3, H.M.S.O.*
6. "Farm Machinery Trends in the U.S.A." Winter 1945-46. *Agricultural Engineering Record, H.M.S.O.*
7. HIGGS, C. "Farm Machinery in Germany & Denmark." *Agricultural Engineering Record.* Spring 1946. *H.M.S.O.*
8. WRIGHT, S. J. "Recent Developments in Agricultural Machinery." *Jour. Roy. Soc. Arts.* Vol. XCIV 1946.
9. WRIGHT, S. J. "The Next Phase in Agricultural Mechanization." *Jour. Farmers Club.* Part 7, 1945.
10. "Specification and Development of Machinery and Implements in British Agriculture." *Agricultural Machinery Development Board.* March 1946.
11. "Machinery Capitalization." *Agricultural Engineering Record.* Spring 1946 *H.M.S.O.*
12. "Farm Carting." *Agricultural Engineering Record.* Winter 1945-46. *H.M.S.O.*
13. "Tractor Duty." *F.M.E. Observations and Notes. N.I.A.E.*
14. "1944-45 Tractor Costs & Performance." *Edinburgh & East of Scotland College of Agriculture*, June, 1945.
15. "Tractor Design." *Automobile Engineer.* July & September, 1945, April 1946.
16. SAUVE, E. C. & MCKIBBEN, E. G. Studies on use of liquid in Tractor Tyres I & II. *Quarterly Bulletin Michigan Agricultural Experiment Station*, Vols. 28 & 29, 1944 & 1945.
17. "The Tractor Industry." *Farm Implement & Machinery Review*, Jan., Feb. and March 1946.
18. "Driverless Tractor." *Implement & Tractor.* May 18, 1946.
19. SANDERS, H. G. "Thorough Cultivation." *Modern Farming*, April 1946.
20. ROGERS, W. S. "Soil Cultivation: How much and why." *Agriculture*, June 1946.
21. KELSEY, C. W. "Rotary Soil Tillage." *Agricultural Engineering*, April 1946.
22. GREENE, J. M. "Some Rotary Tillage Applications." *Agricultural Engineering*, April, 1946.
23. SHAWL, R.I. "Rotary Ploughing as Seed-bed Preparation." *Farm Implement News.* March 14, 1946.
24. "Weed Control with a Weeder-Mulcher." *Agricultural Engineering Record*, Spring 1946. *H.M.S.O.*
25. STREET, A. G. "Silage and Hay." *Agriculture.* July 1946.
26. "Silage-making Mechanization." *Agricultural Engineering Record.* Spring 1946. *H.M.S.O.*
27. HODGSON, R. W. *et al.* "Methods of Harvesting and Preserving Forage Crops." *Agricultural Engineering.* May 1946.
28. "Barn Haydrier." *Agricultural Engineering Publication No. 6 Tennessee Valley Authority.*
29. FRUDDEN, C. E. "Factors controlling moisture removal in Barn Hay Curing." *Agricultural Engineering.* March 1946.
30. DUFFEE, F. W. "Problems of distributing air through Chopped Hay." *Agricultural Engineering.* May 1946.
31. HENDRIX, A. T. "Resistance of hay to Air Flow, etc." *Agricultural Engineering.* Sept. 1945, March 1946 & May 1946.
32. STEINBURGER, G. W. "Airflow in main duct of Barn Hay-drying System." *Agricultural Engineering.* May 1946.
33. CLYDE, A. W. "Distribution of air in Long Hay." *Agricultural Engineering.* April, 1946.
34. TURNER, C. N. "Resistance of hay to Airflow, etc." *Agricultural Engineering.* April 1946.
35. RAMSER, J. H. & LEHMANN, E. W. "The curing of hay in Stack by Forced Air." *Agricultural Engineering.* April 1946.
36. MILLER, R. C. "Air Flow in drying Baled Hay." *Agricultural Engineering.* May 1946.
37. ANDERSON, H. "Seven years of Hay drying experiences." *Agricultural Engineering.* April 1946.
38. MAYNE, J. E., HUME, M. J. and WADSWORTH, V. M. "Pick-up Baling on a West Yorkshire Farm." *Agriculture*, May 1946.

39. "Harvesting by Combine." *Technical Bulletin No. 5 National Farmers Union.*

40. "Windrow Harvesting." *Agricultural Engineering Record.* Spring 1946. *H.M.S.O.*

41. "The Harvesting of Grain by Combine & Binder." *Proc. Inst. Brit. Agric. Eng.* Vol. III, 1945.

42. "Combine Harvesters in S.E. Scotland." Edinburgh & West of Scotland College of Agriculture, Sept. 1945.

43. "Bin Ventilation." *H.M.S.O.*

44. "Pneumatic Grain Conveying." *Agricultural Engineering Record.* Winter 1945-46. *H.M.S.O.*

45. "Threshing by British & American Machines" *Farmers Bulletin No. 10. Farm Economics Branch, Cambridge University.*

46. Bell, R. W. *et al.* "The effect of shearing sugar-beet seed on labour requirements etc." *Quarterly Bulletin Michigan Agricultural Experiment Station.* Vol. 28, 1945.

47. West, W. J. & Wright, S. J. "Root Harvesting." *Scottish Agriculture,* July 1946.

48. "A Potato Deflector for Elevator Diggers." *Agricultural Engineering Record.* Summer 1946. *H.M.S.O.*

49. "Sugar Beet Harvester Development." *Agricultural Engineering Record.* Summer 1946. *H.M.S.O.*

50. "Sugar Beet Harvesting in the U.S.A." *Agricultural Engineering Record.* Summer 1946. *H.M.S.O.*

51. "Grass Drying in Sweden." *Technical Bulletin No. 3, National Farmers Union.*

52. "Grass Drying 1945." *Technical Bulletin No. 4, National Farmers Union.*

53. Cameron Brown, C. A. "The Electrification of Highland Agriculture." *British Electrical and Allied Industries Research Association, Technical Report W/T9.* 1945.

SOILS AND FERTILIZERS

THE literature on soil science and the production and use of fertilizers grows so rapidly that in a short annual review it is possible to pick out only a few sample papers to illustrate some of the main lines of progress. In a science largely devoted to interpreting natural conditions and practical experience there can be very few individual advances as fundamental or as spectacular as those occasionally made in the pure sciences or in their industrial or medical applications. Most of the papers published necessarily deal with the details of a group of experiments in the laboratory or field, or with the soils and crops of a restricted area. A useful guide through the mass of papers is provided by the quarterly abstracts entitled "Soils and Fertilizers," published by the Imperial Bureau of Soil Science, and subsequently listed in title only in a decimal subject-classification in the Bureau's *Bibliography of Soil Science, Fertilizers and General Agronomy.* The fourth volume covering the years 1940 to 1944 has recently been issued. A useful supplement to these abstracts is provided by monographs and symposia on individual subjects, such as the Technical Communications of the ten Imperial Agricultural Bureaux and those prepared for the numerous International and Imperial Conferences held during the last year or two. During the Empire Science Conference in 1946 convened by the Royal Society, there were symposia on current problems of agricultural science and on soil conservation. Much attention was also given in this Conference and the official sectional conferences which followed, to the pressing problem of securing better machinery for diffusing scientific knowledge so that the individual specialist or practical man could more readily find the items of prime interest in his work. In England and Wales the setting-up of the reorganised National Agricultural Advisory Service as from October 1st, 1946, should gradually provide the means for ensuring much closer contacts between farmers and research workers, for their mutual advantage.

I. SOIL SURVEYS AND LAND CLASSIFICATION.

Any consideration of soil problems and every act of practical husbandry necessarily involve some system of classifying soils or land, even though this may be based on nothing beyond traditional experience. As the range of contacts increases and new practices have to be considered, it becomes essential to find some more objective basis for recognising the similarities or contrasts between soils in different areas. A farmer needs to know how far he may expect to repeat on his own land the experience of a neighbour or the results of an experiment elsewhere. Governments and planning authorities need to know the actual or potential values of various sites. In this country we have so much well-established practical experience of our fields that there was until recently little call for any more formal examination than was provided by occasional opportunities for adjusting rentals, changing tenancies or buying farms. Now quite new problems must be faced. It is agreed on all sides that the fertility of our land is a national asset that must be conserved and, if possible, improved, but it is becoming increasingly necessary to decide how to compare the economic and social value of a new town, factory or aerodrome with the potential value of the agricultural land

lost. Again, it may be necessary to compare the costs of an expensive drainage scheme with the likely gain in productivity of a whole region or to decide between afforestation and hill-farming for definite classes of land. All these considerations demand some acceptable system of land classification.

In many countries without the landlord-tenant system some substitute for rentals had to be found as a basis for rural taxation. Land has been classified for this purpose for at least a century in Germany, India and many other countries. Where agricultural settlements extended rapidly during the nineteenth century, as in the United States and Russia, there was a compelling need for some technical information about the soils of new areas, and this led to the first scientific treatment of soil surveying. In the older countries the farmers' need for advice on the use of newer materials, machines and methods led to attempts to classify soils by chemical, physical or biological analyses in laboratories or experimental stations. These early systems inevitably emphasized the physical and chemical properties and the geological origins of individual soils. Over vast continental areas it seemed that a more satisfactory basis would be provided by interpreting the various characteristics of the soil section or profile in relation to the conditions under which the soil had been formed. One school aimed at building up a pure science treating soils as natural bodies without regard to questions of productivity. Within the last dozen years or so there has been a marked reaction against this extreme view, especially in the United States and the Soviet Union, in favour of giving more emphasis to classifying for land-use. G. V. Jacks, Director of the Imperial Bureau of Soil Science, has recently reviewed the whole subject in a Technical Communication (No. 43) entitled "Land Classification for Land Use Planning." The general problem is, first, to decide the most appropriate methods for describing those characteristics of soils which may be regarded as inherent and substantially permanent, and, then, to consider how the information which has been catalogued, classified, and mapped, can best be combined with the relevant economic factors, which, by their very nature, cannot be either permanent or capable of being foretold. Some systems aim at combining both kinds of information into a single figure in much the same way as judges may use a score-card in the show ring. If the information is sound, this method may work admirably for solving specific problems, such as the choice between two alternative sites for a factory or forest, but it can have little general value since it is impossible to find "weighting factors" for individual features with more than local or temporary significance. Systems of rating for individual factors have, however, proved useful for estimating relative productivities, because the results can be checked and the methods kept under constant review by comparison with practical experience in both old and newly settled areas.

When the classification is intended to aid planning for drastic alterations in the methods of using land, there is much to be said for keeping the various categories of information as simple and as distinct as possible. This will allow the readjustments to be easily made and will render the broad lines of the plan more intelligible to those most directly concerned in having to live and work under the new plan. The experience of the Tennessee Valley Authority is of great interest in considering both the technical details required for planning land-use and the much more difficult problems of strategy and tactics in making the plan and carrying it into effect. D. E. Lilienthal in his Penguin book "T.V.A." emphasises that the planners must not aim at a completed blue-print. They should start from things as they are, point a general line of development and be ready at all times to revise the details in determining the next step. "The people must be in on the planning. . . Not one plan. once for all, but the conscious selection by the people of successive plans."

A good example of the technical review of the agricultural problems of a large region is afforded by B. A. Keen's *The Agricultural Development of the Middle East*, which is one of

four reports (Ref. 1) made to the Director-General of the Middle East Supply Centre in 1945. This book will interest many without immediate concern in the Middle East, because it shows how quite general agricultural problems bear on the well-being of people living under highly contrasted cultural and economic conditions. It also records the progress made in developing a number of novel systems of agricultural production. Keen breaks away from the purely geographical treatment and, instead, discusses such questions as the obstacles to agricultural improvement, methods of raising agricultural standards, scientific and technical problems, and the supply and development of agricultural information and advice, with illustrations taken from all the countries concerned. In this way he has described and compared a number of isolated large-scale agricultural developments, some of which may prove of the greatest value as models for other parts of Africa and India. It would be difficult to find elsewhere accounts of many of these Middle East schemes, *e.g.*, the irrigated cotton of the Sudan Gezira, the Jewish agricultural settlements of Palestine, the Italian colonisation of Libya and the co-operative societies of Cyprus.

Brief reference may be made to two other recent books. S. Graham Brade-Birks' admirable and cheap little book " Good Soils " gives an excellent introduction to those aspects of soils which form the basis of soil survey systems. L. Dudley Stamp's "Britain's Structure and Scenery " in the " New Naturalist " series gives a most attractive and well illustrated account of the geographical features and geological history of our land and includes an elementary introduction to modern soil classification.

R. Glentworth and H. G. Dion (Ref. 2) have briefly described the methods and present position of soil survey in Scotland. All the soils fall within the podzolic " Great Soil Group." They are, first, grouped into Associations by the geological nature of the parent material from which they were derived, and each Association is then subdivided into about seven Associates, according to the degree of natural drainage. The soil types differentiated by the drainage conditions are those which the farmer commonly recognizes as soil differences in his fields. They form the fundamental units which the soil surveyor maps. It is hoped that a soil map of Aberdeenshire prepared in this way on a scale of one-inch to the mile will be completed in 1946.

In Scotland the two principal soil-forming factors—parent material and drainage—together with all the vegetational and other conditions necessarily associated with them, provide a comparatively simple basis for classifying and mapping soils, but many other factors have to come in where there are greater variations in climatic conditions, as *e.g.*. in many of the African colonies.

Those who may be tempted to over-simplify the technical aspects of surveying soils or classifying land should glance at the appendix to G. V. Jack's Technical Communication, where C. E. Kellogg's " Outline of a U.S. Soil Survey Report " is reprinted from the official Soil Survey Manual of the United States. A good example of the application of these methods to tropical conditions is given by the Soil Survey of Puerto Rico (Ref. 3).

II. SOIL FORMATION AND MINERALOGY

The development of adequate methods for studying soil minerals is essential in estimating the ultimate reserves of plant foods in soils, in following the processes by which soils develop from the underlying rocks and in interpreting some of the most characteristic features of soils, *e.g.*, their power to retain exchangeable bases and to form crumbs. The older petrological methods for identifying sedimentary rocks by their assemblages of heavy minerals have been employed from time to time to distinguish various glacial and other superficial drifts, which provide the parent materials of vast areas of soils in the northern

temperate regions. They have also been found useful occasionally in parts of the tropics where the weathering of rocks proceeds very rapidly. Thus, in Java it is possible to determine the age and potential agricultural value of contrasted but geologically recent volcanic deposits. In the Congo (Ref. 4) simplified methods of determining the mineral composition of light and heavy sand fractions have been found suitable for distinguishing between two classes of land of very different agricultural value: those with sufficient reserves of unweathered minerals and those treacherous soils which carry luxuriant vegetation but are intrinsically poor in mineral reserves. Under high forest the nutrients are fully mobilised and circulate rapidly between the vegetation and the decomposing litter of the forest floor. Once the forest is cleared and much of the top soil lost, the raw subsoil may be very poor indeed, as many early planters found to their cost.

Until recently comparatively little progress has been made in using heavy minerals in studies on the origin and development of soils. J. F. Haseman and C. E. Marshall (Ref. 5), using improved methods on soils derived from loess (wind-borne dust) and other materials in Missouri, have shown how the degree of admixture between these materials can be determined and how the formation of clay by weathering and its translocation within the profile can be followed. The very resistant and immobile mineral zircon was chosen as the best indicator of changes taking place in other minerals.

In a parallel investigation on two other soils with heavy impervious clay in Missouri and Illinois, E. P. Whiteside and C. E. Marshall (Ref. 6) succeeded in dividing the clay fractions of the ordinary mechanical analysis into a number of still finer fractions by adapting the two layer method of separation to the Sharples supercentrifuge. Some of the size fractions differed markedly from others, but fractions of the same size from the same parts of the two profiles examined in detail exhibited remarkable similarities in properties. Several of the modern methods of studying soil colloids by the ultramicroscope, the electron microscope, X-ray patterns and electrical double refraction were employed in attempts to determine the mineralogical composition of fractions beyond the limits of direct microscopic examination. The authors emphasize that no one method is adequate by itself to characterise clay minerals but that all available chemical and physical methods must be employed together. This view is also stressed by G. Nagelschmidt (Ref. 7) in a review of methods for the mineralogical examination of soil colloids with especial reference to X-ray and dehydration methods.

It is now known that the most characteristic minerals of the clay fractions of soils consist of individual unit layers built up in a regular pattern of atoms of oxygen, silicon and aluminium and stacked loosely together like a somewhat untidy pack of cards. In some of the minerals the layers are held apart by water molecules with or without certain exchangeable bases. The way the distance between the layers changes with the amount of water and the kind of base serves to characterise minerals of the montmorillonite group, and may play an important part in determining the physical and chemical behaviour of many heavy soils. It has recently been found by D. M. C. MacEwan (Ref. 8) that the water in both montmorillonite and halloysite clay minerals can be replaced by certain organic compounds, and that the minerals so treated may be distinguished much more precisely by X-ray methods. This line of approach not only provides the clay mineralogist with a promising new technique but points to the possibility that its extension may ultimately provide some satisfactory method for examining one of the most fundamental and important problems in soil science: the nature of the interaction taking place between organic matter and colloidal minerals in the formation of the characteristic colloids of soils and the formation of soil crumbs and tilth.

Two examples of researches on the borderline between soil science and geology may be mentioned to illustrate how these sciences serve one another. The first concerns the first stages in the weathering of exposed massive rocks. It is commonly assumed that the formation of soil from solid crystalline rock begins with a purely mechanical breakdown of the rock, followed by some chemical weathering and then by the growth of living organisms. B. B. Polynov (Ref. 9), the leading Russian soil mineralogist, has suggested that it is impossible to distinguish these three stages. He found that the exposed surfaces of granite-gneiss rocks were colonised by lichens, which absorbed plant foods directly and flaked off fine fragments of rock, leaving a fine powder rich in organic matter, plant foods and clay minerals. This powder provided a medium on which higher plants could grow and soils form.

The second example illustrates how apparently unrelated facts may be interpreted in terms of the history of the land surface through the fluctuating climates and sea levels of the glacial period. A small area of South Australia presented acute problems in geological and soil classification because it contained such contrasted surface deposits as sand dunes, crusts of limestone and bands of ironstone with all the characteristic soils associated with them. There were also peculiar distributions of deficiencies of copper and cobalt in plants and animals. R. L. Crocker (Ref. 10) has shown how order can be made out of what seemed like chaos by postulating that extensive calcareous sand dunes and sheets were built up from an exposed continental shelf when the sea level was much lower than it is now. The sand dunes are assumed to have been winnowed during a later arid period to provide the masses of calcium carbonate which later was cemented together in a wetter period to form travertine. The remaining sands subsequently underwent " lateritic weathering " leaving the ironstone bands. It had previously been assumed that the surface layers of limestone had been formed by the uprising of hard waters. This view is contrary to the results of the researches of B. A. Keen and other soil physicists, who have demonstrated that water rarely rises in soils more than a few feet above the water table. It is also negatived by repeated failures to find the expected water-tables and by the lack of calcium in the underlying sands. Both in soil surveys and soil fertility investigations in newly developed countries efforts should be made to work out the recent geological history of the land surface. Many of the vast ironstone sheets—sometimes termed " laterite "—which cover large portions of Africa cannot possibly have been formed under their present climates and vegetation. They are essentially fossil.

III. AVAILABILITY OF PLANT NUTRIENTS.

Although advisory work based on soil analysis has abundantly justified itself in dealing with the more unusual types of land ploughed out during the war, and in solving problems of allotting extra phosphate and potash to individual counties, farms and fields, those who are most familiar with the methods of soil examination are the least contented with them. Some farmers and even a few of the local advisers may assume that the chemist has only to determine the available plant food by a simple analysis and then by subtraction say how much more is needed for a given crop. The naïve view is not merely misleading but may obstruct progress by bringing soil investigation into disrepute and preventing those systematic field trials, surveys and investigations which are essential if real progress is to be made at all rapidly. The new National Agricultural Advisory Service should soon show the need and provide the opportunity for a more rational approach to the whole subject. Only an almost trivial fraction of the total amount of any plant food in the soil is available to crops at any one time, and there are innumerable complicating factors preventing any simple solution to the problem of estimating the amounts actually available. Many of these must be established empirically by field trials on carefully classified soils.

In several countries reviews have recently appeared on the results of wartime experience of advisory work based on soil analysis. Writing in the Ministry of Agriculture Journal on the successes and failures of current methods, N. H. Pizer (Ref. 11) emphasised the importance of adequate and careful soil sampling in the field. In old grassland and in fruit orchards it is particularly necessary to take samples from successive layers of soil. Cases are not lacking of extravagant, and sometimes even dangerously excessive, manuring in tomato houses. The accumulations of readily soluble phosphate and potash may be many times greater than the normal annual application of fertilizers. Advice to omit one or both of these plant foods temporarily was often followed successfully without reducing either the quantity or the quality of fruit. As a recent addition of soluble phosphate and, perhaps, potash may sometimes have a useful stimulating effect on early growth, it might often be safer, where soil analysis reveals high reserves, to make a drastic cut in the rates without completely omitting any one of the principal plant foods.

In the early years of the war a characteristically ambitious project was initiated in Germany to analyse for lime, phosphate and potash, soil samples taken from every half-acre of agricultural land. Many million soil samples were in fact analysed. A review (Ref. 12) of the difficulties in interpreting the data led to the suggestion that it would be sufficient to classify the individual fields of a farm as poor, medium and rich in a given plant food. By adjusting his manuring the farmer might then aim at bringing all his fields to a more uniform level of productivity.

In Denmark (Ref. 13), where the technique of manuring is highly developed, surveys for lime requirements have been proceeding regularly since 1905. Most farms now possess detailed pH or soil reaction maps, which provide the basis for liming, choice of fertilizers and many other practices. Until the beginning of the war it was customary, as in the United Kingdom, to make soil analyses for phosphate and potash mainly on unsatisfactory soils, and to stick to the older conventional methods in which practical experience had hitherto been expressed. A new development is to apply the most modern methods of soil analysis systematically over wide areas. The standard analytical scheme is used on 100,000 soil samples each year. At the same time the large number of field trials of simple design on lime and fertilizers intended mainly for local interest and demonstration is being replaced by a scheme of more elaborate comparisons between soil analyses and the actual behaviour of lime or individual fertilizers on each of the principal types of soil.

Another Danish paper (Ref. 14) draws attention to the danger of relying too exclusively on plant analyses for diagnosing nutrient deficiencies. Very often a poor crop shows a relatively high concentration (percentage on dry matter) of an element in short supply, just because the deficiency restricts growth. If a small amount of the nutrient in question had been supplied, the crop would have made a more than proportionate response in growth and the additional dry matter produced would have so diluted the extra amount of nutrient absorbed, that its concentration would fall. With still further amounts of the added nutrient the concentration would begin to increase once more until it might finally reach high values. It is suggested that analyses for nutrient concentrations should never be used alone, but in conjunction with cther methods of observation, preferably including the actual response to treatments in field plots or in pot cultures.

In work carried out at Versailles, G. Barbier and his colleagues (Refs. 15 and 16) have queried the common assumption that the increased total uptake of a given nutrient by crops on treated plots affords a sound basis for estimating the efficiency of the fertilizer. The extra uptake of phosphate from rich pockets of soil may be compensated within the plant itself by a diminished uptake from other parts of the soil. The low percentage recoveries of phosphate from most soils are not necessarily due to phosphate fixation but may result

from a purely physiological auto-regulatory mechanism of the plant. In pot experiments comparing superphosphate added to soil contained within a number of small wire cages buried in a large mass of untreated soil with the same amount of superphosphate uniformly distributed throughout an equal mass of soil in other pots, about two-thirds of the added phosphate was recovered from the soil within the wire cages, though the average recovery from the whole mass of soil was, as usual, small. The plants took a large amount of phosphate from the rich pockets and very little from the rest of the soil. Unfortunately the experiment station was bombed before crop yields could be obtained. This kind of investigation has important bearings on the placement and granulation of fertilizers because these methods provide means of ensuring adequate supplies of available phosphate locally in the early stages of growth, even though the ultimate total uptake of phosphate may not be affected. Sometimes the rapid establishment of a crop is of great practical importance as an insurance against adverse conditions later. Another illustration of the advantage from irregular distribution of plant nutrients is given later in this Report in considering the relative effects of coarse and fine limestone.

Direct evidence of the transfer of plant nutrients through plant roots from one part of the soil to another is afforded by physiological experiments in Moscow (Ref. 17). Plant nutrients may be rapidly transferred in both directions between tops and roots, and those taken up from one part of the root system may be excreted somewhere else where the soil conditions are different. Thus, calcium taken from one horizon in a soil may be transferred to another region rich in sodium and lacking calcium, in much the same way that water can move through the plant from moist to dry zones. This effect may account in part for the ameliorative effect of plants on solonetz (" alkali ") soils rich in water-soluble or exchangeable sodium.

It is probable that many of these problems on the borderline between soil chemistry and plant physiology will prove amenable to more critical treatment when they can be undertaken with " marked " or " tracer " elements, which can be followed by their artificial radioactivity. In the meantime it should be obvious that the soil analyst cannot be expected to cover all these complicating factors in the simple extractions he can use in routine analyses for advisory work. All he can do is to compare groups of soils where conditions are generally similar and calibrate his methods and limits by practical experience or by the results of co-ordinated series of field experiments.

IV. FERTILIZER SUPPLIES.

With the release of official statistics it is now possible to follow the annual consumption of fertilizers in the United Kingdom throughout the war years. The Ministry of Agriculture has very kindly supplied data for the total consumption of the three main classes of fertilizers, expressed in terms of actual plant foods. This provides a more complete picture than can be obtained from the returns in the Monthly Digest of Official Statistics. The annual totals are set out in Table 1, together with the total acreages of the three principal classes of agricultural land. The acreages of arable land and of tillage land (*i.e.*, crops and fallow, or arable land *less* temporary grass) provide an index of the progress of the ploughing-up campaign. As the use of phosphate and potash on grassland was prohibited during the war in England and Wales (apart from a small allowance for dairy pasture, in the last year or two), and as only very modest amounts of nitrogen were used on grassland, figures obtained by dividing the total consumption by the total acreages of tillage land may be taken as showing the general changes in the average rates of dressings for arable crops. Similar figures are given in terms of arable land to facilitate comparisons with other periods or other countries.

TABLE I. FERTILIZER CONSUMPTION IN THE UNITED KINGDOM AND TOTAL AREAS OF TILLAGE LAND (CROPS + FALLOW) AND GRASSLAND.

	1939	1940	1941	1942	1943	1944	1945	1946
Million acres, June 4th								
Tillage	8.81	10.49	12.71	13.67	14.51	14.55	13.85	13.33
Temporary grassland	4.09	3.86	3.53	3.83	4.22	4 72	5.33	5.72
Permanent grassland	18.77	17.08	15.11	13.71	12.33	11 74	11.84	11 98
Total consumpton of fertilizers for year ending June 30th in thousand tons plant food								(*Est.*)
Nitrogen	60	77	128	168	171	182	172	167
Phosphoric acid	170	196	233	287	303	344	346	361
Potash	75	85	47	62	73	113	116	120
Average fertilizer dressings cwts. plant food per 100 acres of tillage land								
Nitrogen	14	15	20	25	24	25	25	25
Phosphoric acid	39	37	37	42	42	47	50	54
Potash	17	16	7	9	10	16	17	18
cwts. plant food per 100 acres of arable land								
Nitrogen	9	11	16	19	18	19	18	18
Phosphoric acid	26	27	29	33	32	36	36	38
Potash	12	12	6	7	8	12	12	13
Total consumption of triple superphosphate in thousand tons product	-	—	3	60	89	112	48	—

There was a very great increase in the use of nitrogen, mainly as home-produced sulphate of ammonia, in 1941 and 1942, and towards the end of the war the total consumption was nearly trebled. The average rate of dressing remained substantially constant from 1942 to 1946 at twice the pre-war rate. This represents an average dressing of less than 1 cwt. sulphate of ammonia per arable acre, a very ordinary dressing for cereals in all but the wettest regions, and there is therefore no reason why the rate of consumption should fall appreciably, as long as supplies remain available and the price structure for crops and raw materials remains substantially unaltered.

In spite of the difficulties of importing two raw materials—rock phosphate and pyrites—to make superphosphate, the total consumption of phosphate fertilizers was doubled during the war. The average rate of dressing on arable land went up by one-half to the equivalent of around 2 cwt. war-time superphosphate (18% P_2O_5) per arable acre. Such increased consumption was essential if the effort put into ploughing up was not to be wasted, because much of the old grassland ploughed out was notoriously deficient in phosphate, as in lime, and needed considerably more phosphate than old arable land carrying the same crops. The permit scheme and all restrictions on the use of phosphate fertilizers were withdrawn in July 1946. Now, the immediate need is to maintain the wartime rates of dressing, especially on the newer arable land, and to begin to make good the accumulated shortages on pastures, especially for young stock and dairy cows. The figures in the last line of Table 1 record the rapid increase in the use of imported triple superphosphate to a maximum of 112,000 tons in 1944, when it provided about one-sixth of the total phosphoric acid used. Supplies subsequently dwindled away.

Potash, which came almost exclusively from Germany and France before the war, presented much more acute problems. By 1941 supplies had fallen to almost one-half. The need for potash was then particularly great to ensure the success of potatoes and vegetables, and even of cereals on some of the thin or light soils ploughed out from the chalk and certain sands. In spite of grave shipping difficulties the position had greatly improved by 1944, when, thanks to a special effort, total supplies had gone up to about 50 per cent. above the pre-war level and the average pre-war rate of dressing had again been reached. The farmer who used the available potash on those soils and crops that needed it most, suffered less through the shortage than the fruit grower who used a good deal of potash before the war, but was allowed none under the permit scheme which, incidentally, still remains in force. If and when supplies improve sufficiently to allow the removal of all restrictions, the demand for potash should increase considerably, as many farmers and all fruit growers will have much leeway to make up.

There can be no doubt that improvements in the use of fertilizers through practical experience, advisory work and field experimentation on fitting manuring to the actual needs of specific crops and soils was one of the most potent factors in the success of the food production campaign. Much of what has been learnt will still serve for years to come in improving the yields and qualities of our crops and the fertility of our soils.

Fertilizer supplies in other countries followed very different patterns. The United States were able almost to double their consumption of each of the three plant foods, reaching totals for 1945 of 640,000 (short) tons of nitrogen, 1,368,000 tons phosphoric acid and 746,000 tons of potash. By contrast, Belgium (Ref. 18), which formerly used fertilizers at very heavy rates, was able to keep its nitrogen consumption steady at around 60,000 (metric) tons until 1944, and to increase its potash consumption from 60,000 to 107,000 tons by 1942. By this time its consumption of phosphoric acid had fallen from 70,000 to 21,000 tons. In 1938-39 the average dressing was about 0.45 cwt. of each of the three plant foods per arable acre, a total of 1.35 cwts. with a 1 : 1 : 1 ratio for N : P_2O_5 : K_2O. This was almost three times the rate in the United Kingdom (0.47 cwts. of $N + P_2O_5 + K_2O$ per arable acre with a ratio of 1.0 : 2.8 : 1.2). By 1942 the Belgian ratio had changed to 1.0 : 0.3 : 2.0 and by 1946 the United Kingdom ratio had changed only to 1.0 : 2.2 : 0.7.

The United States Department of Agriculture has prepared at the request of the Committee on National Fertilizers and Lime Policy an admirable bulletin (Ref. 19) on the resources, production, marketing and use of fertilizers and lime in the United States. This includes a factual review of the data with information of basic importance to all who are concerned with or interested in the formulation of a national policy in respect to these materials. The many diagrams vividly present the historical, geographic and agricultural aspects of the production and consumption of fertilizers and lime. There are also many tables showing the consumption of the various classes of material by States, and a bibliography. This bulletin will provide a useful reference volume to all who are interested in anything beyond purely local and immediate problems in soil fertility and crop production. Such reviews are urgently needed elsewhere and it is much to be hoped that the Food and Agriculture Organisations will shortly be able to prepare them.

In the United Kingdom a new Control of Fertilizers (No. 31) Order (S.R. and O. 1946, No. 975) fixed the prices of fertilizers from July 5th, 1946. Attention may be directed to some novel items. The prices of compound fertilizers are defined by fixing standard prices for four National Compounds and for four concentrated compound fertilizers based on ammonium phosphate, and relating the prices of all other compound fertilizers to those of the National Compounds. The standard compositions and prices are given in Table 2.

TABLE 2. *Composition and standard prices of compound fertilizers.*

	N%	Soluble P_2O_5%	Insoluble P_2O_5%	K_2O%	Price per ton £	s.	d.
National Compounds							
No. 1	7	6.5	0.5	10.5	10	11	6
No. 2	9	6.75	0.75	4.5	10	5	6
No. 3	6	11	1	nil	9	2	6
No. 4	4	13.75	1.25	nil	9	0	6
Fertilizers based on ammonium phosphate	N%	Total P_2O_5%		K_2O%	£	s.	d.
	12	12		15	16	5	6
	14	16.5		10	17	7	0
	13.8	42.3		nil	20	14	0
	11	48		nil	20	17	0

The changes reduce the prices of ordinary NPK National Compounds by a few shillings per ton, and increase those of concentrated compound NPK fertilizers by 27s. 0d. per ton, thus narrowing the gap between the two classes when both are compared with the costs of equal amounts of plant foods in straight fertilizers. Even at the new prices the concentrated fertilizers remain somewhat cheaper per unit of plant food

Substantial deductions are made for early deliveries—up to 30s. 0d. per ton for compound fertilizers in July. Although farmers may have had unfortunate experiences with fertilizers setting on storage in sheds, the circumstance has to be faced that current high outputs require the factories to run at full pressure for nearly the whole year, though the demand has an acute peak in early spring. It is not possible to store most of a year's output at the factories, and some of the storage must be done on the farms. It should also be remembered that, when the fertilizer permit scheme is finally withdrawn, manufacturers and merchants will no longer have a semi-automatic indication of the probable requirements of individual farmers. Early ordering and storage on farms are likely to remain necessary for years to come.

The end of the war provided a convenient opportunity for reviewing current practices and tables for assessing the residual manurial values of fertilizers and purchased feeding stuffs for tenant-right purposes. Never since the first Agricultural Holdings Act had purchases of imported feeding stuffs been so low. The recent incorporation of the Central Association of Agricultural Valuers provided the means for applying in general practice any new agreements which could be reached. The Ministry of Agriculture set up a Conference to review the whole subject and make recommendations, and its unanimous report has been accepted by the representative organisations of all the interested parties. As the historical, scientific and practical backgrounds to the main problems involved and the conclusions reached have been discussed elsewhere in this volume, it is unnecessary to summarise them here.

The immediate prospects for fertilizer supplies are still a matter of concern to the authorities responsible for determining production policies and allocations between countries. Before the war one-half of the world production of nitrogen fertilizers came from Germany, Italy and Japan, but at the present time these countries need to import nitrogen and other fertilizers. In a time of grain shortage and bread rationing the proper use of additional nitrogen affords one of the most positive steps towards checking famine and saving life. Fifty-thousand tons of additional nitrogen supplied in fertilizers to the right countries at the right time would yield about one million tons of additional wheat or rice.

The fertilizer allocations of the Combined Food Board for 1945-46 and estimates for 1946-47 (Ref. 20) are given on a global basis in Table 3, together with figures for pre-war production.

TABLE 3. *World production and requirements of fertilizers in million metric tons of plant foods.*

	Pre-war production	*Allocations* 1945–46	*Estimates for* 1946-47 *Production*	*Demand*
Nitrogen	2.2	1.6	2.4	3.3
Phosphoric acid	3.4	3.1	4.1	5.5
Potash	2.4	2.1	3.2	3.3

The 1945-46 allocations were considerably down on pre-war figures, especially for nitrogen. Although, as has been mentioned above, the United States and the United Kingdom had greatly increased their consumption of nitrogen fertilizers, many other countries were in urgent need of much more nitrogen to carry through the Hot Springs policy of concentrating at once on maximum output of grain and other energy-rich foods for immediate human consumption. The reasoned demands presented to the Combined Food Board called for twice as much fertilizer nitrogen in 1946-47 as in 1945-46. Although the estimated production listed in Table 3 shows half the increase called for, it is officially recorded that the estimated production levels may be "altogether too optimistic." They pre-suppose favourable conditions throughout the world, and it is now certain that Germany and Japan will not reach their production targets, if, indeed, they are allowed to run their nitrogen fixation plants. There is danger of a "nitrogen famine," unless the world's nitrogen plants can run more nearly to full capacity, and farmers in many countries can manage to use the ammonium nitrate most of the factories are designed to make. The supplies of potash for the United Kingdom and elsewhere will be limited by the output from the European mines.

Even the difficult production targets for 1946-47 are still far below optimal. It has been officially estimated that to improve the general standard of crop production and to bring crop yields of less developed countries, such as India and China, more or less into line with those of more progressive countries, would require about 9 million tons of nitrogen, 9 million tons of phosphoric acid and 5.5 million tons of potash per annum.

V. LIMING MATERIALS.

The figures in Table 4 give the annual consumption in the United Kingdom of agricultural lime in million tons product and in million tons equivalent calcium oxide (pure lime).

TABLE 4. *Agricultural Lime Consumption in the United Kingdom.*

Year ending June 30th	1939	1940	1941	1942	1943	1944	1945	1946
Million tons product	1.74	1.33	1.49	1.82	4.10	4.64	3.27	3.42
Million tons CaO	1.30	1.00	1.06	1.26	1.76	2.04	1.86	1.96
Mean % CaO	74	75	71	69	43	44	57	57
Cwts. CaO per acre of								
tillage land	3.0	1.9	1.7	1.8	2.4	2.8	2.7	2.9
arable land	2.0	1.4	1.3	1.4	1.9	2.1	1.9	2.1

The total weight of liming materials fell in the first two war years during the main drive for ploughing-up, and then surged upwards again in 1943 and 1944, when the main problem was to improve yields. The gross figures for the tonnage of product are, however, misleading, because they obscure pronounced changes in the dominant forms of liming materials. In 1938-39 the average liming material had about 74% CaO, which means that, after allowing for impurities and moisture, the bulk of the material used was burnt lime.

The heavier rate of liming in 1943 and 1944 was made possible only by using very much more chalk and ground limestone. The latter was either a by-product from rock crushed for other purposes or was ground specifically for agriculture in new grinding plants imported under Lend-Lease. The average CaO percentage then fell to 43 as compared with 56 in pure calcium carbonate. By 1945 the proportion of burnt lime increased once more and, although the total tonnage fell off sharply, the total liming or neutralising value suffered only minor changes from 1943 to 1946. The record of the liming campaign and the general impression of the countryside dotted with white heaps or whitened fields show a different story when allowance is made for the large acreage of acid grassland ploughed up. The average consumption of CaO or its equivalent per acre of arable land in the peak years was no higher than in 1938-39, though the average lime requirement of the arable land had been greatly increased by bringing very acid land into cultivation. Further, the average rate of liming—2 cwt. CaO per arable acre—is less than the figure commonly taken as the average annual loss of lime from the soil in drainage water. On this basis it would appear that the liming campaign had done nothing more than meet inevitable current wastage. The true position is not quite so grave because much of the lime went to very acid land where the immediate benefit was large and the annual wastage well below average, just because the soils remained moderately acid after liming. Nevertheless it must be admitted that the lime subsidy scheme of paying half the delivered cost of liming materials—and more than half at certain periods of the war—has failed in ten years in its main task of wiping out one of the principal limiting factors in soil fertility and crop production. The whole question needs to be thoroughly reviewed by the authorities, the advisory service and the representative organisations of farmers and landowners. The main part of the cost is commonly for transport and spreading, and one solution might be to establish uniform prices at farms throughout the country, as has been done for certain fertilizers. The system of spreading directly from the lorries needs to be extended. In this connection the example of the Southern Provinces of New Zealand merits attention. G. A. Holmes (Ref. 21), in reviewing his experiences in working for County Committees in this country during the war, mentions that the Southern Provinces of New Zealand use liming materials more heavily than any other country. Both production and spreading are mechanised, a 14-ft. box distributor being attached behind a motor-lorry. A couple of boys will usually spread about 40 tons of lime in an 8-hour day and achieve good uniformity. Ground carbonate of lime is used almost exclusively. During the war the demand was so great that a rationing scheme had to be introduced (Ref. 22). Ground limestone was allowed at the rates of 10 cwts. per acre for spring application to swedes, turnips and new grass and at 4 cwts. per acre for top dressing pastures in autumn and early winter. These small dressings on pastures would make good the annual losses. Experiments have shown that 2 ton dressings have a marked effect for at least three to four years and that there is no difference in response over six years between a hard limestone and a soft one. There is no justification for very fine grinding. It is sufficient if at least 50 per cent. of the ground limestone passes a 30 mesh screen.

The extended liming campaign in Britain should be based on a more general use of ground limestone. There are signs, reflected in recent changes shown in Table 4, that many farmers still prefer burnt lime to ground limestone in spite of the manifest advantages of the carbonate form and its dominant position in most other countries. Perhaps the prejudice arises from traditions dating back to the days when the only choice was between lump chalk and burnt lime. Modern crushing and grinding plants can reduce limestone to a most efficient and convenient form. Another contributing factor may be the lack of any word in English to denote " liming materials " as a class. The word " lime " is commonly used in this sense, as in the title " Agricultural Lime Department " of the Ministry of Agriculture, or in the chemists' term " lime-requirement," but some farmers may interpret

the word too literally as meaning " quicklime " and think of limestone as a crude raw material or unfinished substitute. There are many conditions in which ground limestone is more efficient than an equivalent amount of burnt lime. The carbonate form is easier to store and handle, and it can be incorporated with the soil far more thoroughly and uniformly. There is no need to grind the limestone very finely. Although far more field trials on different forms and finenesses are needed, there is already evidence that relatively coarsely ground limestone is peculiarly effective. Indeed, some recent results in Missouri (Ref. 23) suggest that coarse limestone may actually be better than fine. In an 8-year test on a two-course oats-maize rotation with clover sown with the oats and ploughed in for the maize, it was found that 10-mesh limestone gave better crops than 100-mesh limestone. This was true for single dressings at the commencement of the experiment or for repeated small dressings actually drilled with the oats and clover. It is suggested that moderate local irregularities in the soil may be definitely advantageous. Plant roots may obtain their calcium from the neutral soil in the immediate neighbourhood of the coarse particles of limestone and be able to take up their other nutrients more readily from the intervening pockets of acid soil than they could if the whole soil were brought to a uniform lime status. It is well known that overliming may aggravate deficiencies of several trace elements. Intensive liming campaigns have often been followed by an outburst of investigations on deficiencies of manganese, boron, copper and other elements. It would be a very convenient and economic solution to an important practical problem if it could be confirmed for a wide range of conditions that modest amounts of rather coarse limestone are both more efficient and safer than heavy dressings of quicklime or extremely finely ground limestone.

A large number of French limestones ground to varying finenesses were examined for their solubilities in carbonated water (Ref. 24). Chalk and soft limestones were fairly soluble when coarsely ground, whereas compact limestones needed to be ground very finely to have an appreciable solubility. The neutralising effects towards acid soils followed the solubilities in carbonated water.

The results of nearly 1,000 liming experiments in Finland, a country with highly leached soils, have been analysed (Ref. 25). On the heavier soils the pH value was a fairly reliable indicator of the lime requirement, but on light soils the exchangeable calcium content gave a better guide. In the last 20 years the annual consumption of limestone has gone up from 1,000 to 300,000 tons per annum but it is estimated that 80 per cent. of the soils still need lime and that to raise all soils to a satisfactory lime status a million tons will be required annually for ten years, and thereafter about half a million tons per annum. Ground limestone is the only liming material used, and it has been shown to have a similar effect to slaked lime and to be much cheaper. The annual loss of lime from the acid Finnish soils is roughly proportional to the amount of limestone applied. The effects of a suitable lime dressing on crop yields last for at least ten years, during which time from one-third to one-half of the lime added is lost in the drainage water. It was from considerations of this kind in the United Kingdom that the compensation for the residual value of lime in the tables of the Central Association of Agricultural Valuers was changed from subtracting 4 cwts. CaO per acre per annum to subtracting a constant fraction each year. The fraction of one-eighth was chosen for simplicity, though it was fully appreciated that lime lasts much longer on very acid soils.

VI. FARMYARD MANURE AND PLANT FOODS.

In a general review of the problem of using straw to best advantage in mixed farming under Swedish conditions, O. Franck (Ref. 26) suggests that the daily requirements per head of cattle are 4 lb. of straw as bedding with another 13 lb. to ensure that all the urine is absorbed. He recommends adding about $\frac{3}{4}$ lb. superphosphate to reduce the volatili-

sation of ammonia and composting any surplus straw with inorganic nitrogen, the straw being suitably chaffed at threshing. In a large number of Swedish experiments 12 tons of farmyard manure per acre gave on the average about 2 tons of extra sugar beet per acre where no fertilizers were used and about half this amount on sugar beet receiving fertilizers (Ref. 27). The effects of farmyard manure depended on the phosphate and potash contents of the soils. It was shown that to use light dressings of farmyard manure on several crops of the rotation was better practice than to give a large amount to a single crop.

On some very acid Swedish soils derived from drained swamps and possessing high fixing power for phosphate (Ref. 28) it has proved preferable to use superphosphate with the farmyard manure before spreading than to apply the two materials separately. Similar results have been obtained in Vermont (Refs. 29 and 30) on acid soils with a high capacity for fixing phosphate. The soluble phosphate is converted by the bases in the manure into dicalcium phosphate, which is immediately available to plants though protected by its lower solubility and by the mechanical effect of the farmyard manure from too rapid fixation by the soil to almost useless phosphates. Some of the merits of this protection of phosphate are probably obtained in those wetter regions of Britain in which it is customary to put farmyard manure and phosphate fertilizer in furrows, split the ridges and sow swedes. The old proposal to use superphosphate to reduce the volatilisation of ammonia from urine in the open drains of cowsheds and from fresh manure should be re-examined in the light of a possible additional gain from improving the availability of the phosphate added in the manure to acid soils with high fixing powers.

E. M. CROWTHER.

ROTHAMSTED EXPERIMENTAL STATION,
HARPENDEN,
HERTS.

References

1. See also WORTHINGTON, E. B. Middle East Science. ALLEN, H. B. Rural Education and Welfare in the Middle East. WRIGHT, N. C. Animal Industry in the Middle East (in preparation).
2. GLENTWORTH, R. AND DION, H. Soil Survey in Scotland. *Scot. Geog. Mag.*, Vol. 62, 1946, pp. 16-23.
3. ROBERTS, R. C. Soil Survey. Puerto Rico. *U.S. Department of Agriculture, Bureau of Plant Industry*, Series 1936, No. 9, January 1942.
4. LEENHEER, L. DE. An introduction to the mineralogical examination of soils of the Belgian Congo. *Inst. Natl. Et. Agron. Congo Belge Pub. Ser. Sci.*, 25, 1944, pp. 45.
5. HASEMAN, J. F. AND MARSHALL, C. E. The use of heavy minerals in studies of the origin and development of soils. *Missouri Agric. Exp. Sta. Research Bull.* 387, 1945.
6. WHITESIDE, S. P. AND MARSHALL, C. E. Mineralogical and chemical studies on the Putnam silt loam soil. *Missouri Agric. Exp. Sta. Research Bull.* 386, 1944.
7. NAGELSCHMIDT, G. The Mineralogy of Soil Colloids. *Imp. Bur. Sci. Tech. Comm.* 42, 1945.
8. MACEWAN, D. M. C. Identification of the Montmorillonite Group of Minerals by X-Rays. *Nature*, Vol. 154, p. 577, 1944. Halloysite-organic Complexes. *Nature*, Vol. 157, p. 159, 1946. See also, BRINDLEY, G. W., ROBINSON, K. AND MACEWAN, D. M. C. *Nature*, 157, p. 225, 1946.
9. POLYNOV, B. B. The first stages of soil formation on massive crystalline rocks. *Pedology*, No. 7, 1945 pp. 327-339. See also LAZAREV, A. A. *ibid.* pp. 340-437.
10. CROCKER, R. L. Post-Miocene Climatic and Geologic History and its Significance in Relation to the Genesis of the Major Soil Types of South Australia. *Australian Council Sci. Ind. Res. Bull.*, 193, 1946.
11. PIZER, N. H. Soil analysis and advisory problems. *J. Min. Agric.* Vol. 52, 1945, pp. 164-170, 205-209, 270-276, 315-324.
12. WEHRMANN, O., BALKS, R. The assessment of the result of soil investigations. *Forsch-Dienst.* 17, 1944, pp. 608-614.
13. DAMSGAARD-SORENSEN, P. Soil analyses as basis for fertilizer advice. *Tidsskr. Landøkon*, 1946, pp. 141-162.
14. STEENBJERG, F. Chemical plant analyses and their use. *Tidsskr. Planteavl.* 48, 1944, pp. 158-177.
15. BARBIER, G., MARQUIS, A. The evolution of phosphatic fertilizers applied for fifteen consecutive years to a loam soil. A direct measure of the utilization of phosphatic fertilizers by plants. The evolution of phosphatic fertilizers in bare soil and their fate in cultivated soil. *C. R. Acad. Agric.* 30, 1944, pp. 412-415, 416-418. *Ann. Agron.* 14, 1944, pp. 409-424.
16. BARBIER, G., CHABANNES, J., MARQUIS, A. The effect on plants of a local increase in concentration of phosphate ions in the medium. *C.R.* 221, 1945, pp. 710-711).
17. RATNER, E. J. Interaction between roots and soil colloids as a problem of mineral nutrition of plants. Role of the root system. *C.R. Acad. Sci. (U.S.S.R.)* 48, 1945, pp. 64-67.
18. RAGONDET, R. The consumption of chemical fertilizers in Belgium during the years of enemy occupation and, the variations in yield of the principal crops. *Ann. Gembloux* 47,-52, 1946, pp. 2-24.
19. Fertilizers and lime in the United States. *U.S. Dept. Agric. Misc. Publ.* 586, 1946.
20. Report of the special meeting on urgent food problems. *F.A.O. Washington*, 1946.
21. HOLMES, G. A. A New Zealander looks at British Farming. *J. Min. Agric.* 50, 1943, pp. 158-162.
22. BATES, E. M. Liming of pastures. *N.Z.J. Agric.* 72, 1946, p. 79.
23. ALBRECHT, W. A. Plant nutrition and the hydrogen ion ; V. Relative effectiveness of coarsely ground and finely pulverized limestone. *Soil Sci.* 61, 1946, pp. 265-271.
24. LENGLEN. The agricultural application of natural sources of lime after grinding. *C.R. Acad. Agric.* 30, 1944, pp. 167-171.
25. TUORILA, P. Some problems concerned with the question of liming. The lime requirements of cultivated soils in Finland. *Svensha Vall—o. Mossk Foren. Tidskr.* 7, 1945, pp. 83-101, 102-120.
26. FRANCK, O. The straw-humus problem. *Kgl. LantkrAkad. Tidskr.* 85, 1946, pp. 41-53.
27. MELCHERT, H. Farmyard manure trials within the Swedish sugar-beet growing area, 1937-1944. *Socker Handlingor* 2. 1946, pp. 63.
28. ÅSLANDER, A. A Method of phosphate application. *Kungl. Lantbruksakademiens Tidskrift*, 79. No. 4, 1940, pp. 385-398.
29. MIDGLEY, A. R., DUNKLEE, D. E. The availability to plants of phosphates applied with cattle manure. *Vt. Agric. Expt. Sta. Bull.* 525, 1945, pp. 22.
30. MIDGLEY, A. R. The use of sawdust, shavings and superphosphate with dairy manure. *N.-E. Wood Util. Counc. Bull.* 7, 1945, pp. 27-36.

UNIVERSITY EDUCATION FOR THE FARMER

I. THE FARMER POINT OF VIEW.

The recent 'Report of the Committee on Higher Agricultural Education in England and Wales'—the Loveday Report—cannot but raise important and perhaps controversial discussion.

There are two fundamentally different approaches to this subject, that of the educationlist and the farmer. The one looks to produce a graduate with a whole wealth of basic knowledge and the other hopes to see a farmer who can not only farm well, but who can also give a lead to those less fortunate in the countryside.

The Loveday Report appears to take the educationalist's point of view. While it may be right that the man who is going to advise the farmers how best to solve a particular problem should be first a pure scientist and then a farmer; that he should be given a four-year course rather than three years and should, if necessary, enter a university at a later age than at present; while it must be true that this will provide him with a higher standard of education, nevertheless, I am of the opinion that if a reasonable number of prospective farmers are to take up this course, it will have to be one which both from the time and money point of view is practicable. If you add to this four year course a period of compulsory military training, then it will become one which, though ideal, is not within the bounds of feasibility.

University education or any other sort of education, must in the final analysis be judged by its effectiveness in making the student fundamentally efficient in whatever career or job he ultimately pursues. What then must be the qualifications and, more important, the capabilities of the farmer who has been fortunate enough to spend these three years of his early manhood at a university? What do we need, as farmers, from the universities, at the same time bearing in mind that the practical man's approach to education generally must be satisfied if the courses available to him and his sons and daughters are to be filled?

First then, the graduate of a university must be a man or woman who can make a successful practical farmer under ordinary circumstances; one who is able to make a financial success of his farming business under current conditions. There is a great deal of talk about farming being a way of life as much as a business, and that because of this the farmer need not expect to obtain the same financial return for his labours (whether they be mental or physical) as he would if living or working in the town. This attitude of mind brought about the disastrous state of farming between the two world wars. It led not only to a neglected and bankrupt farming industry in this country, but its effects were felt in all those countries overseas whose economies were mainly based on the production of food. It led to that disastrous stampede to the towns of the country-born young man. It led to the present position where the proportion of old men in the industry is so high and, in fact, the proportion of British labour in the countryside is so low, that 25% of our present quite reasonable production is produced by prisoner-of-war labour.

Under modern conditions, with an adequate supply of up-to-date machinery and young labour, the economic output of British farms could be well above the war-time production; but this supply of young labour will never be available so long as the people and the Government of this country think that the returns from farming effort can be 'stabilised' at a lower level than those required in urban industry.

The filling of degree courses in agriculture depends ultimately on the student being able to see a real prospect of a successful business career on the land from which he can get

a return on his capital at least equal to that obtained from the general run of commercial business, and where the cost of that broader education (more expensive both in time and money at the most important stage of his life) can be amply rewarded when he goes into the industry. A degree course which does not fit him for a business career will be of no use to him and will fail in the long run through a lack of candidates, as was not unknown before this last war.

I believe that university training is not necessary to the prospective practical farmer, and that if he is keen and observant he can gain sufficient knowledge from the shorter, cheaper and more practical course provided at farm institutes and agricultural colleges. The training at these institutes should be such that the student leaves knowing that he has a lot more to learn, and that there are scientists and other farmers always ready and willing to give him help.

On the other hand, university training is absolutely necessary for all those who propose to adopt an administrative or advisory career in agriculture, if only for the reason that the basic knowledge provided by the degree course will give them a constant guide as to what is fundamentally right or wrong in all the problems that may confront them. Conversely, it would be disastrous to the industry if it were thought that the broadest possible education were unnecessary.

Agriculture has been treated as a life apart by the average citizen for much too long. It is essential to the welfare of the agricultural industry, as indeed it is to the welfare of the country, that there should be the closest collaboration (both social, economic and scientific) between industrial and agricultural workers at all levels. If the universities can provide that common meeting ground at a time of life when minds and habits are being formed, then both sides will have gained for all time. Perhaps that is one of the reasons why so many committees have stressed the necessity of future agriculturists being trained alongside students aiming at other careers. Segregation at any stage must take away these advantages. They should meet in the lecture room and mix in the other social activities of a university life, for this is the only real way of learning, and so understanding, the other man's point of view.

But a university course for a prospective farmer cannot be provided just for the sake of mutual understanding. A degree course in any subject must be such that the fundamentals of that subject are common knowledge, and so in agriculture the natural sciences must form the basis of education. The question is how far should these sciences predominate in the teaching at the expense of practical study ?

In many cases in the past agricultural economics was taught as a rather vague though perhaps fascinating theory. As far as my memory of the treatment of this subject in my time at the University serves me, the part that agriculture played in the national economy was of little importance ; the part that food played in the national economy was rarely mentioned and the relationship between town and country was as remote in that teaching as it was in fact in the minds of those who governed the country.

If the modern farmer is to get the most out of university education, then he must be taught all that is necessary for him to take a lead in securing a place for his industry in the business economy of this country and of the world.

But apart from this wider aspect of economics, it is certain that unless he makes a practical success (both financially and technically) of farming, then his influence on the larger aspect will be proportionately reduced. In the countryside where everyone knows everyone else, not much notice is taken of those people who like to speak of the wider aspects of life if they are unable to make a success of their own business.

In the last twenty years a whole wealth of knowledge has been built up on the business economics (if I may call it that) of farming. At all the universities with agricultural

departments, agricultural economists have been appointed ; their work has taken them out more and more on to farms ; farm surveys have been made in growing numbers ; progress has been made in the difficult problem of commodity costing, and a stage has been reached where the Government has been prepared to base its long-term policy for agriculture on the foundation of guaranteed prices negotiated not by the old ' hit and miss ' methods, but on factual data drawn from farms all over the country. By means of these facts it is possible to-day to balance the returns from different types of farming. In a year or two more, when world conditions are more stable, it should be possible to strike a sufficiently accurate balance to give encouragement to one type of production without ruining the other.

All the figures and surveys are available to the universities (they are taken from actual farms). They can and should be used to the greatest possible extent in the teaching in order to show to the student that it is possible to farm well and lose money, but they must be taught how to farm well and make money.

The enormous amount of research and investigation which has taken place during the last few years, under the influence and drive of war, should be used to the utmost to fit that student for the hard and competitive world in which he has to make his living. But the teaching should go beyond this.

The agricultural industry has begun to realise that its interest lies not just in production but also in the distribution of its produce. There can be few (if in fact there have been any) industries which have taken so little interest in their own products after they have left the place of production.

Under the influence of the Marketing Boards a little (though it was very little) progress was made in this direction. A few individuals, especially in horticulture, had made an intensive study of this side of the business, but in the main the farmer left his products to the mercy of those whose business interests lay not in the welfare of the producer, but in getting as much as was possible out of the margin between what the consumer was prepared to pay and what the producer was obliged to accept.

If the agricultural industry in this country and elsewhere is to be the foundation of world prosperity, as it alone can be, and if the standard of living in this country and all over the world is to be ' consistently ' raised to a level at which nations can live at peace, then the first consideration must always be the price paid for the primary commodity. The second consideration (and this affects more the standard of living, while the first has a more direct influence on employment and trade) must be to see that the consumer gets that product in the form he wants it and at the cheapest price economically possible.

Again, under the drive of war the Ministry of Food must have collected a mass of information on the economics of distribution. This information must not be used just for the benefit of the Government but for the benefit of all. It must be made available to universities who might well undertake further research into the problem and so benefit all students.

If the university graduate in agriculture is to be properly equipped to make a success of his business, then it is as important that he should be supplied with the basic facts relative to the distribution of his products as it is that he should be informed on the most economic methods of production.

My first submission was that the graduate must be so equipped that he can make a financial success of his business. What then is the second consideration ?

It may well be that in the future the recruits for the farming industry will be drawn to a greater extent from urban homes. If there is stability in the industry, and if the returns are sufficiently attractive to cover the risks involved, then it is certain that new blood will come in from this source. This is essential on the labour side; from the management side it could do an enormous amount of good.

In these days a new outlook is required in all walks of life, and the countryside is no exception. Anyone who had experience of War Agricultural Executive Committee work in the first years of the late war will remember how difficult it was to get the ploughing campaign going and the tremendous opposition there was to the changes required in production. Farmers after years of neglect had forgotten that the soil of the country was there to be tilled. After the first eighteen months a new atmosphere was felt and as year succeeded year the difficulties disappeared, initiative came back, the old skill returned, and to my knowledge in many cases it was the comparative newcomer to agriculture who showed the way.

Now a graduate in agriculture who is farming on his own account should be able to enter the industry without making those fundamental mistakes which are always so expensive in the farming business. It cannot be right that after spending at least three years of his young life at a university, he should be deposited on the land to learn by his own mistakes. A degree course must fit him for a job whether it is in law, in medicine or in agriculture. He should be equipped with such knowledge as is necessary to ensure that he knows what is fundamentally wrong, whether it is in physics or biology, economics or just technique.

I should never like to suggest that a graduate could be taught all that there is to know about the farming business ; practical and theoretical farming are poles apart, farms and soils vary. The seasons of the year make so much difference, but the treatment required both for crops and stock calls for a considerable amount of specialised knowledge. It is surely necessary that the graduate should at least be prepared for these problems which will arise on the purely practical side as soon as he starts farming on his own. It may be that the practical application ot science is not thought to be the job of the university. Nevertheless, as I have mentioned once before, a graduate should be fitted to his job and a satisfactory balance must be struck between the two approaches.

In the past, some universities teaching agriculture have had no farms of their own. In some cases where there were farms they were situated so far away from the universities that they became a separate part of the university life in the mind of the student.

It is essential that the graduate should know from practical experience, or at least by actual observation, the conditions of soil and weather which will affect him when he is farming. If he comes from an urban home this is even more essential. It seems to me that as far as is practicable the teacher of the theory should be in a position to illustrate his lectures in the field in the same way as the medical student receives his practical training in the hospital. A great deal more of the teaching in the universities should be illustrated on the farm, and considerably more use should be made of the farms centred round them, so that a variety of farming methods, farm conditions, farm economics and mechanisation methods can be shown in a way that is more lasting than that obtaining in the lecture room.

The university farm can and should be used to the full for the detailed study of the soil and cultivation, and of breeding in relation to livestock. But farm types, soil types and different methods of management should be illustrated in practice by using the many farms in the neighbourhood. It is only by these means that the graduate can understand the practical problems with which he will be faced and will be able to recognise, when the time comes, the conditions with which he must deal.

The third and possibly the most difficult practical farming problem for which the graduate should be prepared is the management of labour. In these days of high wages it is becoming the most important item of farm management. To what extent can it or should it be taught in the degree course ?

It is, I suppose, reasonable to assume that a student who takes a degree course in agriculture with a view to farming on his own account will have sufficient capital to farm on a fair scale and will therefore employ considerable labour. Certainly if he has not that capital

and can only farm in a small way he can never expect to recover the cost (whether in time or in money) of that extended education.

The economic teaching will certainly help him to compare labour and output on different farms and under different systems and being based on fact can, if necessary, be illustrated in the field. The part that the machine can play towards increasing output per man, and the developments taking place and required, can be taught in the lecture room. One of the most important angles of this subject is the danger of over-mechanisation. How often does one see the over-mechanised farm go down because the overheads of replacement are more than the farm can carry! All this is a most important, if not a vital part of the education, which should and must be part of the graduate's training if he is to profit by that wider education.

But none of this touches the actual management of labour and it would seem that this can only be learnt by actual experience. The craftsman in an industry will respect the boss who understands that craft. It is not absolutely necessary that the graduate should be able to carry out the job himself (he can learn that later), but he must and should know when the job is being well or badly done and the reason why.

Life on a farm is very different from life in a factory. The farmer lives and works with his men. He will in practice know their domestic problems as well as their capabilities for work if he is to get the most out of them and have a contented farm, and no successful farm can be other than contented. Then he has got to earn the respect of his labour, and this again can only be achieved by experience. The lecturer can therefore only point out the necessity of this particular attainment.

In my opinion the graduate farmer would be well advised to spend at least a year on a farm as a pupil before taking up farming, if possible in the area in which he intends to farm. It is unfortunate that farmers who habitually take pupils have a reputation for using them as a source of cheap labour. Certainly the pupil must work, if for no other reason than to understand how the workers think, and what things are important in their everyday life. But the graduate should aim at working on a farm where he can live with the farmer and learn from him how to employ labour, how to manage labour, and how to deal with the everyday problems which arise however well the business is organised.

Perhaps this may suggest that in my opinion the practical side of farming is more important than the theoretical or scientific side. That is not so. If I am to discuss the university graduate in agriculture from the practical point of view as opposed to the scientific and educational aspect, then it is incumbent upon me to point out the problems which face that graduate, and which to my mind should be safe-guarded against by teaching at university level and they should be brought into relief.

If the university graduate is to prosper as a farmer, and is to benefit from his university training, and is to repay the cost of that education, then the sciences behind animal and crop husbandry are all vitally important. He should know much more than the ordinary farmer of the chemistry, biology and physics which are fundamental to the practice. He should recognise, however, the limitations of his knowledge and should know when to seek further advice. He is first a farmer and secondly a scientist.

The student who takes a degree in agriculture with the intention of becoming a scientist or advisor should be first a scientist and secondly an agriculturalist. The danger to the farmer graduate is that under the influence of his scientific lectures he may become too much of a scientist and fail dismally when he has to put the results of his learning into practice. Farming is essentially a practical business, studded with practical problems. Failure to recognise this so easily results in financial disaster, and if that should come about, then what to my mind is the primary object of education and in particular higher agricultural education, will have failed.

On the whole, therefore, I am of the opinion that the raising of the level of scientific education in the agricultural course at universities is unlikely to benefit agriculture as far as the practical farmer graduate is concerned. The detailed knowledge of the basic sciences is not necessary to him, and the time taken up in the study of these sciences would have been better spent on the more practical side of the industry.

No amount of scientific knowledge can outweigh in importance the more practical and economic knowledge required in farming if the graduate of a university is to be turned out as a practical farmer. He will neither make an economic success of the business, nor will he be in the position to benefit the industry generally by the advantage which should be gained as a result of that longer education.

The tendency for raising the age at which students should enter farm institutes or colleges or universities can be taken to a limit at which no one can afford to take part. Some time or other it is necessary to start working for one's living. It is certainly true to say that in no business does one ever cease to learn. The farmer will be the first to recognise the value of a university training for his sons and daughters, and if he personally considers that these courses are beyond his means, or are not sufficiently practical, then no amount of propaganda can make the course a success.

It is essential therefore that those whose job it is to plan curricula should strike that happy balance between scientific agriculture and practical agriculture which can result in a graduate who can make a business success.

Leaders in the industry are urgently needed. The university background must be of the very greatest help, but it should be available to the largest number and not to the limited few who can perhaps afford the time as well as the expense which is involved.

J. N. McCLEAN.

Flexcombe,
Liss, Hants.

II. THE UNIVERSITY POINT OF VIEW.

Education is essentially a personal matter. The appropriateness of a University education for farmers as a whole is not a subject for consideration. It is rightly stressed in the Report of the Committee on Higher Agricultural Education that the majority of farmers may not have the inclination or aptitude for the work involved in a University Degree course ; but while this is true it would be most unfortunate if it detracted from our appreciation of the value of a University education for those practical farmers who have the inclination and the ability for University studies and who find the life and atmosphere of a University congenial. The advocacy of a University education for those farmers for whom it is appropriate must not be weakened by the fact that there are farmers for whom it is not appropriate; on the contrary, as will be explained later, the fact that most farmers do not take a University course makes it all the more important that some should.

There is a second preliminary matter about which it still seems necessary to remove a misunderstanding although the error has already been many times refuted. A University course is not intended to, and never could, produce a practical farmer. Skill in craftsmanship and management can only be acquired by practice and experience, but, while the practice of farming can only be learnt on the farm, it is the contention of this article that a University education for those practical farmers to whom it appeals will not merely add theory to their practice but will enhance the value of their practical knowledge and experience.

University Education.

There are two chief characteristics of University education and they must be fully understood and appreciated before any adequate consideration can be given to the question of University education for farmers. The two features that differentiate Universities from Technical Colleges and other institutions for vocational training are :—

First, a University is not merely concerned (some would say not even chiefly concerned) with the acquisition of knowledge for its obvious and immediate usefulness, but rather, to quote the usual phrase, with " the study of the truth for its own sake."

Second, a University student is expected, in addition to studying the subjects of his own choice, to live in social and intellectual intercourse with students of all other subjects. It is for this reason that most Universities require several years of residence as well as an examination attainment before they will confer their Degrees.

The Study of Truth for its own Sake.

It is this first feature of University education that so frequently prejudices the practical business man against it. On the face of things it does rather plausibly appear to some economically-minded industrialists as though the study of matters that are not known to be linked up with some economic or utilitarian problem and with the acquisition of the bread and butter of life, is fantastic and useless ; but if on the face of things it looks like that it is seen, when properly studied and considered, to be far from fantastic or useless. Before proceeding to discuss this it is worth while to note that not only have farmers criticised University education as being too academic for practical men but at times in the past University dons and professors have resisted the introduction of such subjects as Agriculture as being too commercial and utilitarian for an academic institution. Farmers on the one hand have been apprehensive that a University education would undermine practical efficiency and University professors on the other hand have been apprehensive that such a subject as Agriculture would desecrate the academic atmosphere of a University and pervert the outlook of University staff and students. The fact that Agriculture has now long been successfully established in many Universities is not due to a straight contest between University people who favoured it and farming people who didn't : it is due to the vision and enterprise of those who had experience both in academic and in farming circles and who realized that the Universities could serve the industry of Agriculture without any weakening of their academic functions and in a way that would strengthen rather than weaken the practical ability of the farmers.

While on the face of things academic study in a University may appear to some to be inappropriate to the practical man, there are four factors involved in academic work which when they are clearly discerned must make a strong appeal to every far-sighted and enterprising man of business.

Two of these factors are personal and concern the training of the individual student. In the first place there can be no doubt that people for whom University courses are appropriate do by the study of the science relating to their industry develop very much their interest in that industry and all that pertains to it. There are some who are a little shy about stressing this point and who fear that the practical man will condemn interest for its own sake and ask for something profitable, but no practical man who honestly consults his own experience can deny that interest in one's work is one of the main incentives to efficient and profitable work. No experienced employer will take on a man who works merely because he has got to and without any real interest, if he can get someone who combines with the necessity for work some measure of the love of the work itself. No consideration can be more practical than this and it is one of the most important factors in the training of a University student.

In addition disinterested study at University level does discipline and develop the power of thought and the ability to reason soundly and without bias. This it must be admitted is a factor of outstanding importance.

The other two factors involved in the much misunderstood outlook of a University in studying the truth for its own sake, concern, in the case of the Agricultural student. the industry rather than the student personally.

In the interests of future developments in any industry there should be built up as complete a reserve of knowledge and understanding of its materials and processes as possible. Certain it is that many industrial developments would have been impossible but for the work of those who seek knowledge for its own sake, because without their work the background of essential knowledge would not have been there when the time was ripe for industrial development.

Finally, no one can foresee what will be learnt, by those who pursue disinterested study, that will provide the basis of economic industrial development. The pursuit of knowledge for its own sake has in fact been justified by the amount of utilitarianism that has been forthcoming as a by-product.

In every University research work is going on providing the background for future industrial developments and leading to new ideas which can be applied to industrial developments and it is eminently desirable that some people who are going into each of the important industries should have intimate and personal contacts with this type of work. It should not be impossible to convince a hard-headed public that the pursuit of knowledge for its own sake has in fact a large economic and industrial value, but the full guarantee of the value of this work can be given by those who are equally acquainted with it and with the needs of the industry. There should therefore always be some potential practical agriculturists who are in intimate contact with agricultural academic developments and who can speak to their fellow practitioners about its real value.

The University Environment.

Equally important to the successful study of his own subjects is the fact that the University student is in daily association and in frequent discussion and conversation with students taking other subjects. The value of this lies largely in the fact that in any walk of life if a man is to be successful, and particularly if he is to have the responsibility of leadership, he should have some appreciation of the place of his particular work and industry in relation to human life and thought as a whole. This is especially important in the education of those agriculturists who are going to be statesmen in their industry, for it cannot be denied that many members of the farming community have been isolated in their thoughts from the general conspectus of life and no one can really see the economic problems of his own industry without some appreciation of the fact that his own industry is not the whole of life nor the whole of economics. It is very true, as a Yorkshire farmer has put it, that "you can stay at home till you know now't."

The Content and Standard of a University Course for the Practical Agriculturist.

There is unlikely to be disagreement with the Report of the Committee on Higher Agricultural Education in their assertion that an Agricultural Degree Course must be based upon the natural sciences. While this is true, however, it may lead to some misunderstanding, a misunderstanding, it is to be feared, which has to some extent adversely affected Agricultural Degree Courses in the past. If a course is to be relevant to Agriculture then clearly it must include the study of certain sciences which are involved in the agricultural industry. It is quite impossible, however, to include in a University Degree Course everything that a practical farmer would find it useful and interesting to know and to understand.

Agriculture from the scientific point of view is an extremely diverse industry. In involves Bacteriology, Botany, Chemistry, Economics, Entomology, Mycology, Veterinary Science, and no one can make an exhaustive study of all these subjects. Nothing like so many sciences are implicated in any other industry, and University Degree Courses relating to those industries can usefully be based on one or two sciences, but even in regard to Degree Courses relating to those other industries it would be a great mistake to suppose that the course should include everything that the future practitioner needs to know or will find useful. Even if this were humanly possible, which it is not, at the time a student took the course, it would become defective with development of knowledge and changes of understanding and outlook. The purpose of the course is not to give the maximum amount of factual knowledge but rather to train a man's outlook, interest and powers of thought so that his mind may grow and develop to the fullest extent as he pursues his career. Graduation at the end of the University Course is " only the end of the beginning " and the real value of the work and experience in the University develops throughout the rest of his career.

The designing of an Agricultural degree course has always been regarded as a difficult matter and this arises largely from the desire to include all the relevant sciences as well as husbandry and economics. Universities with Agricultural Departments have given a great deal of thought to the content of their degree courses in Agriculture and changes in curriculum have from time to time been made, partly as a result of experience and partly because of developments in the application of a particular science to Agriculture. There has, for instance, in some Universities been a marked tendency to increase the time devoted to Bacteriology because in recent years the subject has become one of primary importance particularly in dairy farming. A good deal is said about the content of the Agricultural degree course for the practical farmer in the Report of the Committee on Higher Agricultural Education. The committee expresses its sympathy with the view that the economic aspect of farming should have more stress in a degree course and quite rightly supports the suggestion that there should be instruction bearing on the life of the rural community and the place of agriculture in the national economy. The committee, however, deprecates any reduction in the teaching of science in order to provide more room in the timetable for the economic and social aspect of agriculture and rural life.

There never will, in the writer's view, be a satisfactory solution of this problem until it is fully realised that it is quite impossible, even if the degree course is extended to four years, to cover the social and economic aspects of agriculture and rural life and to cover the complete syllabus in the relevant sciences. The degree course must contain courses in husbandry, in economics and in some science, but it cannot cover the whole ground of all of them, and in any case there is no final definition of what the whole ground is. Moreover, there is no fixed design, including some agriculture, some economics and some science, that is most appropriate to all students. Some students, for example, might appropriately study more economics and less science than others.

The fact must be faced that a degree course is a *beginning* in a student's training and has no finality in itself, and Universities that arrange degree courses for practical agriculturists should see that the student necessarily takes some agriculture, some agricultural economics and some agricultural sciences but apart from that should allow as much latitude as possible for students to take alternative subjects with more of this and less of that according to their individual interests and aptitudes.

N. M. COMBER.

THE UNIVERSITY,
LEEDS.

FIXED EQUIPMENT ON THE FARM

THE most important farm buildings are the cottages and the farm house. Until the farmer's wife and the farm worker's wife are happy and able to contend well with their day to day cares, we will not be able to make our land produce as much as it should. Apart from this overriding problem, rehabilitation of farm buildings is the ever pressing one for the good of stock, crop and worker. It is this aspect of fixed farming equipment with which the following article deals. In order to avoid redundancy I shall only mention the admirable contents of the English and Scottish Farm Buildings Committees' Reports in passing; for the same reason I have avoided diagrams of layout with the flow of farm traffic set out therein. There are few things more irritating to the reader than constant cross reference; in any case nearly all my readers will be familiar with these reports.

We know all too well that the shortage of labour in the building trade and the shortage of materials means that the utmost care, economy and forethought must be used in planning the adaptation of old, as well as in the development of new buildings. Therefore, like all Gaul, the problem of farm buildings can be divided into three parts, namely :—

1. Can we do without buildings ?
2. Can we re-model existing buildings ? If not—
3. What forms should new buildings take ?

On the face of it the first question may sound absurd, but I do not by any means think that we often enough ask the question, " Is your building really necessary ? "

We have three groups on the farm to consult here, namely animals, soil and man. Up to date there has been insufficient study of the requirements of animals themselves. For instance I think we have tended to coddle our horses in warm, dark stables. I remember that, in the winter of 1917 on Salisbury Plain, we kept a regiment of horses in barrack stables and about 250 remounts under a tin roof only, on an exposed hillside. The weather was bitterly cold with frost and snow. The horses in the stables were constantly going down with pneumonia, colds and chills, etc., in spite of most careful animal management. On the other hand I cannot recall a single case of illness of any sort in six weeks among the remounts exposed to the elements. I have since discovered that wherever there is reasonable shelter from wind and some fairly dry corner for standing, horses of all sorts do better kept out the year round. I believe also that, where the soil is light, cattle kept out on the Hosier Bail system have fewer ailments and are less liable to react to the tuberculin test than cattle lying in during the winter.

This is only the result of personal observation. On the other hand some very interesting tests are at present being carried out in the United States. Montana probably has the coldest winter climate in that country, in fact the cold there is beyond the conception of most Englishmen. Temperatures very often run to 40° to 50° of frost. Dairy cows have there been tested by living in a paddock and coming in only to be milked, against animals living in hygienic thermostatically controlled cow-sheds. Although the final results have not yet been arrived at, the experiments having only run for two years, authorities were generally agreed that the difference in milk yield would not vary as much as 5% between the two groups, either way. On the other hand it was felt that the better health enjoyed by the animals living out would more than compensate for any slight loss of milk yield, should such prove to be the case. A similar series of experiments were going on in the dairy state of Wisconsin. There the winter climate is relatively milder than in Montana but infinitely more severe, both in cold and snowfall, than anything which we have in this country.

Here again results appeared to parallel those in Montana. It is only fair to point out that during the experiments the usual custom in the United States of feeding hay *ad lib.* was observed.

Therefore it is my belief that, so far as the animal is concerned, it would be better kept out of doors the year round and only brought in to standings at milking time.

However, here the type of soil and rainfall must be taken into consideration. Wet climate and heavy soil are limiting factors. We have learnt how to grow much improved grass at a much increased initial cost for seeding on a three or four year ley. This means that we cannot afford to poach potentially valuable and costly pastures. Even where a winter bottom of old pasture is available in proximity to the cow-sheds, the heaviness of the soil may make it impossible to keep the animals out in a good state of health, merely because they have to make their journeys to and fro in a quagmire.

Then there is a most important and final consideration—those who look after the cows. No man likes " sploshing " through muddy ground in filthy weather. That indeed is the great objection to winter milking on a Hosier bail, even when the soil is suitable. Going across half a mile of open fields at 5.30 on a winter's morning to do the milking may well outweigh the fact that after milking there will be little or no mucking out and other unpleasant jobs to do, as would be the case in a cowshed. Yet one should never forget that where a Hosier bail can be used the year round the cow has already mechanised the dung cart by leaving her manure exactly where it is wanted. I do not think the general lower average of milk obtained by using a bail is due to milking out of doors anything like so much as it is due to the mass production methods necessarily employed and the small amount of individual attention which can be given to each animal, both as regards breeding and feeding ; in fact I have known a Hosier bail of sixty Shorthorn cows with a recorded sale averaging 900 gallons of milk per cow.

Therefore when we ask, " Is your building really necessary ? ", it may not be for the animal but it may be for the soil and almost certainly demands a compromise in favour of the workers in attendance. Yet I am also convinced that much can still be done in reducing the number of expensive functional buildings required for livestock. For instance a good dry quarry or chalk pit can very well be used for fattening pigs and I have indeed seen sows producing strong large winter litters in perfect health, when *force majeur* had dictated that their only shelter would be one sizeable heap of straw per farrowing sow on open pasture. I think the same principle applies to wintering store cattle. Although it is probably necessary to keep calves weaned at birth warm and under cover, anything over five or six months can easily be kept in a spot that is dry and sheltered from the wind, with only a minimum of overhead cover. This again allows manure to be made close to the spot where it may be needed.

Summing up, I should say that we have not by any means reached the limit of useful improvisation in reducing the number of buildings which we may require for livestock of all sorts. In my view it would be unsound, in these days when horse traction on the farm is disappearing, to think of putting up expensive stables, when all that is required is a sheltered paddock with a dry standing.

Where we are going to improvise with rough shelter and temporary buldings we should try to see that the workers are saved long journeys in exposed conditions and deep mud. Even that consideration should be balanced by the amount the workers are saved in mucking out fixed buildings and expensive handling and re-handling of manure and feeding stuff, *i.e.*, on outlying parts of the farm it may be of great advantage to grow winter food for young stock at a spot where their own manure can be returned to the land where it is most needed.

One of the most important factors in doing away with expensive functional buildings for livestock lies in having good dry approaches. Gateways and so forth, can often be stoned,

gravelled or chalked fanwise, with immense advantage to livestock and the comfort of their attendants. The mere stoning of the gateway itself is not enough. This is one of the odd jobs on a farm that should be constantly kept in mind for slack periods when other work is not so urgent, and should be part of farm routine.

Now we come to the second part of our problem. Can we re-model our existing buildings by adaptation and improvement ? On the first question it became clear that the housing of livestock is complicated by the individual aspect, soil and rainfall of every farm. All these problems are equally with us in re-modelling. Added to that there is the infinite variation from farm to farm of the style, state of repair, lay-out and general suitability of existing buildings. Very often, on looking at the accretion of sheds, barns, yards, granaries, etc., which have grown up during the centuries on a farm, one is tempted to say, " Put the bulldozer through the lot," and few can deny that in many cases it would be the ideal solution. Yet here again there are a variety of considerations which should make us think most carefully. Foremost there is the question of shortage of material and labour. Then there are the ever-changing demands of new methods in farming to take into consideration. The ideal lay-out of to-day may very well be as difficult and out of date to-morrow as the buildings of our forefathers are now. I have seen more foolishness in building *de novo* than in almost any other branch of farming. Elaborate complete new lay-outs are far more often attempted by the newcomer with capital than by the man who has spent some years on the farm before he attempts it. Of course once a man has got used to second best he is very inclined to continue to " make do " out of habit, even when the chance for better building occurs.

When I first started to farm, twenty-three years ago, I took over a set of buildings designed for the days of corn and sheep. They were in imminent danger of collapse ; so imminent that they did in fact collapse when I put a rope over one of the rafters and hauled hard with three or four men at the end. Using the old site I then erected a model thirty-cow dairy, tower silo and manure pit with an overhead dung carrier. Looking back on them they were not bad buildings and would to-day be quite suitable on many farms, but in the long run they proved utterly unsuitable for what I needed. In the first place they were in the bottom of a valley which was the collecting centre for the rain run-off of about five hundred acres and, therefore, totally unsuitable for a large head of stock. Secondly I had a long uphill battle to get water when I wanted it, and not, when I did not ; thirdly milk, grain and dung all had to be hauled uphill before they could reach market or fields respectively. The use of water in washing down and cooling in a Grade A. dairy ultimately presented me with a drainage problem that was all but insoluble and so, although the buildings were not badly planned in themselves or extravagantly built, I found it cheaper six years later to abandon them completely. Two winters on the farm, before I put up my new buildings, would have convinced me that a new site was necessary. On the same farm I had a small set of rather dilapidated outlying buildings on higher ground. Here I did no more than make good the bottom of the yard and do a few necessary repairs, but these buildings are still in use as a young stock centre and granary ; quite probably they will continue to be used successfully for the same purpose for years to come.

This may be only a personal record of the foolishness of inexperience, but I have since observed how often it occurs even when much more experienced farmers and farm managers take on a new farm with plenty of money behind them. Often, as a War Agricultural Committee member, I have seen the new owners' proposals for complete new sets of farm buildings where high-class stock are going to be kept and new machinery employed. Luckily for the owners in many cases the original plans had to be scrapped, owing to the shortage of labour and materials, because, splendid and satisfying as they may have appeared

on paper, I felt convinced that in a few years' time they might have become white elephants, redundant and unworkable.

It is easier to over-build on farm buildings than anything else. The truth of this can still be seen in that on nearly every farm to-day the replacement value of existing farm buildings, for insurance purposes, comes to more than the saleable value of the land and buildings. In other words, the capital value of drained and reclaimed land has been spent several times over on buildings in the course of two centuries for the sake of more efficient production. Each change in farming practice has demanded new buildings. Each era of prosperity has produced large new structures. Each era of depression has seen the loss of many old ones by the attrition of neglect. So, before putting the bulldozer through our existing buildings, we must be extremely careful about future trends and always ask ourselves what we can reasonably " make do " with at a moment when building is so difficult.

The first principle, when faced by a specific problem of insufficient, ill-adapted or dilapidated farm buildings, is to examine it :—

(*a*) From the aspect of possible future aids, such as water and electricity, where these are not present.

(*b*) In the light of farming requirements likely to be permanent.

To deal with (*a*) first, the situation of the farm in relation to water, electricity and adequate housing is of prime importance. It is probable that a cheap electricity supply will ultimately reach 60% or even 75% of our farms, but on the remainder electricity at least will remain an expensive luxury to obtain, owing to isolated conditions or slowness of development. So too a good cheap piped water supply on many out-lying farms may well be beyond the practical scope of development, and, generally for the same reasons, a supply of good cottages for labour may not be easily forthcoming. The equipment costs of a remote upland farm (I am not speaking here of the hill farm which presents a parallel but different problem) might very well be double that of a farm situated with easy road access, on a good water main, reasonably close to some centre of population.

Generally the upland or off-lying farm is on relatively infertile land. Until we are much more certain of our fate as an intensive agricultural country it would be unwise to do more than the bare minimum in the way of adapting farm buildings or building new ones in such situations. Probably the answer for these farms is some grain, if the land is suitable, combined with young stock and/or sheep. Here few farm buildings are necessary ; we should have good fences, shelter belts and adequate dry storage for the minimum of implements, seeds, feed and manures, a few boxes for stock together with reasonable road access. In certain cases these farms could doubtless be managed from a distance, with modern transport, but there will always be a number of individuals, both farmers and workers, who prefer a more solitary life and are not necessarily influenced by lack of amenities such as electricity and water sanitation. Nothing can be more futile than trying to push intensive dairy farming into such places. Apart from the very much greater need for water the days of milking by hurricane lantern are over and electricity will be almost as necessary as water for the dairy farm of the future. These more remote farm lands will probably always be our reservoir for sheep and store cattle.

There remains the problem of converting more accessible farms which were designed for a different purpose in an age when time and labour were of much less account. For instance, where grain and crops are sold off the farm, the position of the farm buildings is more important in relation to the main road than to the shape of the farm. Ideally the farm buildings should be close to the centre of the farm, but in practice, as far as cash crops are concerned, provided buildings are close to the public road, they could be almost as ideally situated on the centre of a semi-circle and even, with modern transport, on one of the narrow sides of a rectangle. Where dairy cattle are to be kept, it is necessary to have the

main buildings easily drained and situated where there is easy access for rotational grazing all round the farm as far as possible and, above all, where a good water supply can radiate not only to the buildings but to the surrounding fields. If the old buildings are really badly situated, from the point of view of stock, that would be a factor in deciding whether to "patch up" or build *de novo* on a more suitable site. This again will have to be considered in relation to the siting of the farm house or stockmen's cottages.

Coming to (*b*), namely farming requirements, it is probable that there will be a permanent demand for improved quality milk; therefore, other things being equal, it is reasonable that trouble and expense should be incurred in the adaptation of buildings for clean milk. If the type of farming is dependent mainly on the individual caprice of the farmer and what is perhaps only a temporarily profitable market, then, in my view, adaptation should be as cheap and improvised as possible. An extreme case of this sort might be the farm turned over to pigs on the strength of available swill from a nearby military camp. In between these extremes of permanent and temporary policy there are a great many graduations. For instance, the stockless mechanised grain farm will demand large new implement sheds and probably a grain drier with silos, perhaps also a grass drier, which can mean a very large outlay per acre on fixed equipment; this would have to be undertaken against a relatively insecure future First of all it has not yet been finally demonstrated that this sort of farming, even with our mild climate, can continue indefinitely: secondly, because grain can easily be transported and stored, the future of a profitable market for grain in this country is very precarious: thirdly, to-day's methods of drying grain and grass may easily be out of date within a very few years. Therefore if there is a chance of using available drying plant and storage room, either in conjunction with a neighbour or a local grain drying depot, it would appear to be sounder, even though it may be temporarily inconvenient, to do this, than to erect one's own buildings until the future, both of technical and economic trends, becomes clearer. There is little doubt that more and more of our grain will eventually be combine-harvested. By itself this will mean revolutionary developments in drying and storage and may probably make the present pioneers' able but individualistic methods out of date. Later I shall discuss an all round compromise when considering the form new buildings should take.

Thus we can arrive at some general principles in considering the adaptation of each individual farm to modern needs. First, if the farm is remote and of a low inherent fertility it would appear to be wise to do as little as possible in the way of expensive building and to treat it as a reservoir for supplying the more intensive and accessible farms with young stock, treating the arable side of it mainly as a matter for contract work, unless the farm is suitable to be turned into a large scale store stock ranch. Second, if the farm is reasonably well suited for intensive agriculture, then more expensive adaptation can be faced, provided that the existing buildings are suitably situated for labour and stock, drainage and water supply, Third, make-shift improvisation and a certain amount of temporary inconvenience is probably the sound policy where the main dependance is upon specialised production, the future of which is uncertain.

From this it is possible to consider more in detail the types of adaptation that are needed. The first question is how best to save the labourer as distinct from saving labour. I believe it is possible to be grossly extravagant in designing or adapting buildings merely to save man hours. A farm cannot be divided into specialised functions, even were it desirable, as can be done on the assembly line in a factory or even in an office. The moment one starts thinking only in terms of man hours, the following can easily occur. Figures can prove that by putting up, or adapting, a building to one specialised purpose it is possible to save "x" number of hours per year, which will more than pay the 5% interest on the cost of building. The next thing that happens is that those saved hours are probably wasted

in standing around or, what is more probable, that half the time the farm is definitely short of labour to do necessary jobs which generally crop up, but are not allowed for when making out a schedule. Much work is therefore scamped and the workers more dissatisfied. I have seen ultra-mechanised labour-saving farms abroad where the work for the few labourers who remained meant nothing but sheer slavery, albeit highly paid. Also a costly functional building may deteriorate rapidly and become obsolete. The interest thus saved in lower labour costs may ultimately be turned into a complete loss of capital.

On the other hand where workers can have dry conditions and move stores with the minimum of back-breaking effort and inconvenience, and where they only have to walk ten steps in a direct line instead of fifty round innumerable dark and muddy corners, then a real saving is accomplished, both on behalf of the worker and the farmer. Sometimes it is not the building which causes the unnecessary steps so much as bad organisation of labour on the part of the farmer or the worker himself. For instance, it is a very common thing to see, in a well designed cowshed, the feeding passage blocked with bales of hay or other paraphernalia while the worker goes up to feed behind each individual cow in turn saying, as he does so, "Git over Dolly." In such a case designing a cowshed with a feeding passage is sheer waste of capital. I remember going over the only non-modern, ricketty building on a famous farm in California. This was an old barn converted into a mill in three storeys. Across the lintel on the first floor was strung a number of washers on a wire. Every time the miller went upstairs he transferred a washer from one side to the other; at the end of the day he counted his washers to find out how efficiently he had organised his own labour —a lesson which we might all take to heart; but this is digression.

The ordinary farm building lay-out in England is generally three or four sides of a quadrangle with off-shoots. Here the first necessity is a sound bottom over the yard. If the buildings are shallow then possibly the best use for them, as far as stock are concerned, is for young stock and calving pens, using a barn or bigger building as a store for bulk and concentrated feed. On the whole it is probably better not to mix this type of yard with milking byres. On the other hand the buildings may have at least one or two sides sufficiently wide to adapt as a single row of cow standings so that the dairy for milk cooling and washing up may be placed either at one end or where the two sides join. Provided the mixed food need only be brought a very short distance it is probably a very useful compromise in adaptation, in order to avoid a complete new set of buildings.

It may be possible to have rough cow standings, if the cows have to lie in, and to adapt one smaller building as a milking parlour. This is only a practical procedure if the cows have a good dry and convenient gathering ground for exit and entrance during the summer. It makes for much cheaper adaptation than an individual stall for each animal to be milked in, and probably facilitates mucking out and conservation of urine in the litter. In the West country, where less straw is grown and rainfall is high, cattle will probably have to be kept in winter tyings as there would not be sufficient litter for open or covered yards. Although, with careful management, and use of litter other than straw such as bracken and other waste organic materials, lack of straw should not present an insuperable obstacle. Where animals can lie out the year round I would always be inclined to build or adapt a milking parlour rather than a range of expensive milking sheds. The more we go in for high quality of milk the more likely it is that the milking parlour, which is very much easier to keep clean, is an answer to our difficulties.

Another solution is to use existing buildings for store cattle and down calvers and to build a new milking parlour with a good shelter yard for wintering stock close by, so that the same feed stores can be used for all stock, with economy of labour. There is not space here to go into the controversy of horns versus de-horning when dairy cattle are kept in winter yards. When a very large herd of cattle is kept winter straw yards present a space problem

that is admittedly difficult. I do not believe that more than 40-50 cows is a good dairy unit; above that milk is a matter of mass production, individual care in breeding and feeding is far more difficult. Except in cases where very large herds are concentrated, a good sheltered yard with feeding mangers suitably arranged under cover is a great saving of expensive functional buildings. A yard divided into 10-15 cow units and arranged so that one cart or trolley can feed into racks and mangers on each side is, of course, the ideal, with food stores close to one end. Here too is the right place for the silo, should such be used. In these yards better dung can be made than in a shed, and it needs handling only once. Uprights of the shelter shed should be placed for plenty of room longitudinally, and laterally for a tractor to work with a manure scoop attachment for loading. The partitions dividing the yard should be in easily movable panels for the same reason. Above all the bottom should be sound and well drained. Diagrams of layout and movement flow are clearly set out in the Farm Buildings Committee's Report.

At this point I think it is worth while going more deeply into the milking parlour controversy. I will readily concede the difficulties of horned cattle standing about in a fairly confined space before milking, and the fact that it may be more difficult for the cowman to give individual attention to each cow as she comes in. On the other hand your good cowman should be able to do this just as well with a milking parlour as on the cowshed dairy system, and your bad cowman will not be any good anyway. The question of time allowed for feeding concentrates according to yield is to my mind a much more serious consideration. I would, therefore, advocate that the milking parlour is designed so that the animals can remain for at least nine or ten minutes to consume their concentrates before passing outside. Thus, if there are three milking units being operated I would have a milking parlour of twelve standings, which would allow for three cows being milked, three being stripped and six finishing their feed before the batch was turned out to make ready for the next detail. If two units were in operation I would give an eight stall parlour and so on to four stalls on the small fifteen to twenty cow farm. My reason for this is that no matter what the changes may be in farming there is probably no farm which will not want, according to its size, to milk a minimum number of cows. Therefore the milking parlour is never likely to become redundant as might happen if a sixty cow dairy were fully equipped for milking. Moreover we have had many changes in the demands of Public Health Authorities as to the equipment of cowsheds. It would be easier and cheaper to alter a milking parlour to meet new regulations than a large cowshed. It is certainly very much more easy to keep it clean and to sterilise the pipes and so forth from the machine milker. In addition a minimum of labour for recording and cooling is needed; while we continue to wash down, there is much less waste of urine and water, and very much more comfortable living conditions for the cattle for the same reasons. On the whole quick milking methods on the American system are best suited to the milking parlour.

Nothing is more uncomfortable for an animal than lying, even though bedded down, on recently swilled concrete. The Americans have overcome this acute discomfort for the animal by using gypsum instead of the hose on the standing and the dung walk, with excellent results in bacterial counts; but it may take years before such a principle is acknowledged in this country. However there can be no objection to using this method where cows are merely lying in without being milked in the same place. Again on many American farms dunging gutters have no outlet and the manure from them is merely scooped up each morning with all its urine. So that in building expensive cowsheds, according to present day requirements, with elaborate drains, we may be making a costly permanent building for a temporary demand by Public Health Authorities. Indeed it may be possible one day to go back to the far more comfortable rammed chalk or clay as a lying ground for animals than cold and not too sanitary concrete. On this question of making rough floors

and providing a good dry bottom to the yard it might well be possible to use the rolls of steel mesh strips employed for temporary air landings and passage by army vehicles. Also it is well worth considering these for our gateways and farm roads.

Among other practical points to be considered in adaptation there is the question of widening sheds to make cow standings. Personally I do not believe in the economy of doing this for the whole pitch of the roof must be altered and a complete new wall set up, which makes for very little saving in the end. So too, unless the walls and foundations are extremely good and properly situated, I am against taking off the existing roof in order to heighten the building to get the necessary air space, unless of course the roof is in such a state of disrepair that it would have to come off in any case. Where a roof wants very serious repair and is thatched I would always advocate taking the thatch off and the use instead of something like corrugated asbestos or asbestos slates, but I would not use corrugated asbestos where the building was unlikely to be permanent as the sheets are easily broken when the building has to be taken down. There is another small practical point of great importance for the comfort of the men ; where a boiler house is being put in for sterilisation, it is advisable to have it large and airy enough for the men to be able to dry their clothes in wet weather and, if necessary, be able to sit down for a meal or a smoke at odd moments when off duty. If not, there should be some room available for this purpose.

If the barn is to be modernised it should be done with an eye to the future use of electricity for sack conveyors, small grinding engines, and so forth. A great many of our large old barns are full of waste spaces because there is only hand labour for stacking sacks and bales. A very great deal could be done with lateral rollers and portable escalators for sack and bale hoisting, especially where electricity is available. Too little attention has also been paid to the small self-propelled prime mover on large farms for internal movement of heavy or bulky materials. Such a prime mover might easily make an inconvenient building tolerable and useful. The same machine might also work in garden, orchard and rowcrop. Through passage for lorries and carts is also advisable. If roots and heavy sacks of grain are going to be stored far too little attention is often paid to the strength of the walls and timbers against which these are going to rest.

On a farm where pigs are going to be carried along with dairy cattle I am against the adaptation of any main buildings for the pigs as our aim is gradually to bring all our herds up to attested standards. Either pig buildings should be completely improvised from old chalk pits, quarries or bale straw yards, or they should be temporary portable units, away from all contact with the cattle. Even suitable off-lying buildings are not very satisfactory for pigs, if they can be better used as a young stock depot.

My personal belief is that those who are breeding their own dairy animals will more and more find it useful to draft out their elderly matrons or animals with three quarters, which are of the right type from which to continue breeding, as foster-mothers for the calves in outlying buildings. No amount of propaganda can persuade me that young calves do better on calf substitutes, or even on whole milk, than on the udder. Therefore, in my view, the outlying farm buildings could very well be turned into a foster-mother centre, where old cows may be drafted to continue breeding and turn their milk production to use in rearing calves. When the calves are old enough to be turned out to grass it is advisable to put them on to pastures not grazed by the dairy herd, thus eliminating much risk of disease. Adaptation of outlying buildings for these purposes can be very cheap and serve a most practical end, provided always there is housing nearby for the attendant workers.

Before leaving the problems of adaptation and improvisation, I can warmly recommend the plans for buildings designed by the Home Office out of surplus A.R.P. material, especially the designs for a stock shed and an implement shed. If these surplus materials are still

available, they may solve some pressing difficulties without undue expense in the next few years. It is, however, to be hoped that deliveries will be made at one time of all the materials ordered, and that they will be up to the samples recently on view in South Kensington. Again surplus tubular scaffolding, used by the military in defence works, can serve admirably for the skeletons of buildings for smaller barns and store houses.

Finally we come to the question of new buildings. Here my personal views are very decided. Up to fifty years ago the great barn was the centre of the farm, certainly its traditions run back to the Middle Ages. Here grain could be thrashed under cover and all through the winter, corn could be stored and all the farm's indoor activities could take place. Again in Denmark and many parts of Europe the big single building is the outstanding feature, even on the small farm. All through North America the tendency is to concentrate nearly everything on the family farm into one large barn. Thus I think it is clear that the central barn has stood the test of time. The reason why its importance has diminished in Great Britain in the last two generations is due to the very great changes in farming practice. The decline of mixed arable farming and the rise of specialised farming between the wars, based on imported feeding stuffs, has laid the emphasis on functional buildings, for which the older, often very old, barn was unsuited; but I believe that the large barn in a new form will become once again the heart of the farm.

I have already discussed the danger of purely functional buildings becoming redundant on a change of farming practice. Therefore a sound conception in new building appears to me to be a barn, suitably sited, which can be adapted to any use at any time. The old ones were built with many timbers, intersections and bays. The Americans have evolved a traditional two storey barn of vast dimensions. The ground floor generally houses all the livestock on the farm throughout the winter. Because of its breadth and depth it is generally dark and not ideal. Above the ground floor is a small agricultural cathedral nave with completely unencumbered floor space, often about 40 ft. by 80 ft., in breadth and length, and very often 25 ft. to 30 ft. high. Into this goes the year's crop of hay, much straw and often the milling equipment as well. The advantage of this type of two storey barn is apparent for the American winter climate, in that the overhead covering of hay and straw keeps stock warm throughout the coldest winter: but it provides a good many difficulties of ventilation; where the buildings are of wood, there is great risk of fire and loss of livestock. It would not seem necessarily to be a suitable building for ourselves, for the saving in roof space by two storeys is largely lost by the cost of timbers and floor necessary to take the weight of hay and overhead stores. Moreover lateral movement of fodder and concentrates can be just as economical as vertical movement by gravity.

If, on the other hand, we could use the general plan of the top floor as a model for constructing a single storey shelter on the ground, we would have a really useful all round building. It is possible, using steel, timber or concrete principals, to build a shell which can be as wide as 40 ft. and as long as is desired, without having a single interruption in the floor area. There is no need to have one building for implements, another for manures, a third for feeding stuffs, etc.; they can equally well, and more conveniently from the labour point of view, be under one roof. Moreover the construction can be so strong that an overhead carrier depending from the roof ridge can be used to convey fodder at any height desired. It can also be used to store lighter vehicles and implements overhead and out of the way when not needed. There is probably no more cumbersome and inconvenient way of storing light implements than the system we used with our old narrow bay cart sheds. The heavy implements, like tractors and rollers, can easily be stored in a lean-to against the long side of the barn.

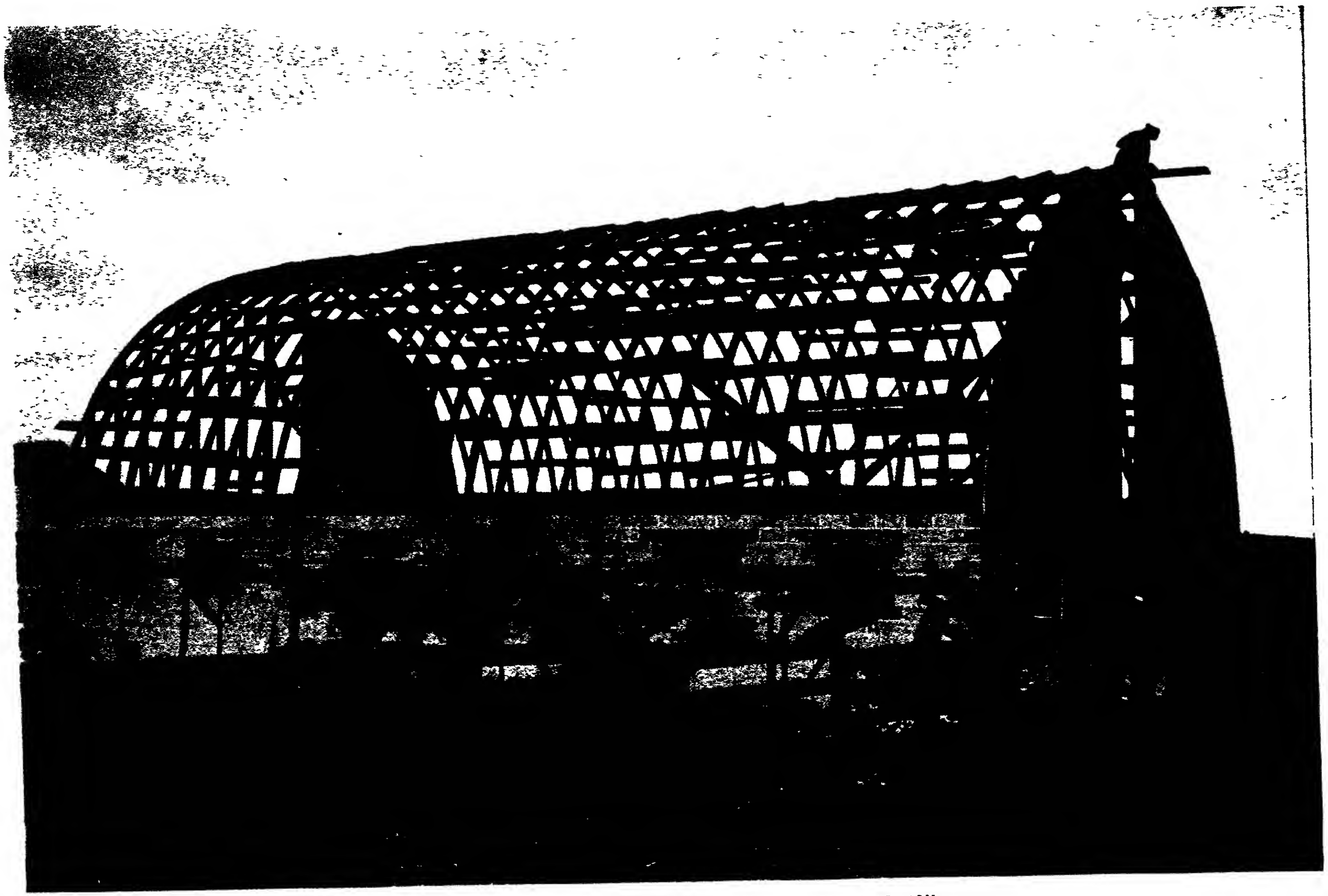
In my view it would be a good thing if such buildings could be standardised in general design so that firms, whether working in steel, timber or concrete could supply principals for

framework to a farm at any time and, where desired, the filling in of wall and/or roof between the principals. The following suggested dimensions for standardisation are made as a basis for consideration and not as a dogmatic finding. In our country I believe the requirements of the cow should be made the basic unit. On the whole a 4 ft. standing is the right width for most breeds of cow: 3ft. 6 in. is too narrow. Again an 8 ft. ceiling, provided there is adequate light and ventilation, is suitable for a milking parlour or single line of standings. Even if 8 ft. is considered too low as ceiling it is still a good height for the eaves upon which to lay a concave ceiling. Again an 8 ft. length is a suitable one for a cow standing or lying down. Thus if the walls were to be built of any kind of sheeting these should be 8 ft. by 4 ft., which is a unit that is easily handled, except in the case of concrete. There should be two standard widths for such a building, say 20 ft. for the small farm and 40 ft. for the larger farm. The distance between principal uprights should be 12 ft. The height of the roof would be standard, in the Gothic shape shown in the accompanying photograph, or a hipped gambrel roof, and strong enough to bear an overhead carrier with a hoist of at least 15 cwts. At one end a door, sufficiently large to allow ingress for any farm implement, should be made. If possible it should have a similar door at the other end. If the building is a long one it would be wise also to have at least one pair of doors, opposite each other, in the centre of the sides, big enough to take a tractor and manure loader with ease. The barn should be so sited that expansion is possible at one or both ends. Here we would have a building that is at once permanent and flexible in that it can be extended at will and the internal fitments altered to meet changing requirements.

Since writing this article I have seen a barn of this type on a large farm in Switzerland which in many ways is an advance in design on the others I have seen. It is single floored, about 90 ft. by 75 ft. There is a central nave unencumbered, about 30 ft. high, with, in this case, a conveyor belt for hay under the roof ridge. The width of the nave is about 30 ft. and the arch Gothic in shape. The roof is of relatively shallow single gable span covering the whole width of the building. On each side of the central nave there is an aisle, about 18 ft. wide and about 16 ft. to the eaves. The construction was in timber of heavy dimensions and so designed that aisles and nave were strengthened by each other. This building appeared to present fewer problems in roof building and in prefabrication than the ordinary Gothic or gambrel roofed barn. It appeared to be adaptable to laminated principals, concrete or steel construction, in smaller sizes even to tubular construction. It provided an all-purpose central nave with two long wide aisles, which could be used in bays for storage or in one uninterrupted length for cow standings through which a cart or tractor could go the whole length without obstacle. It was in fact three all-purpose shells under one roof. This particular barn was being used for six different purposes at the same time and over part a second floor had been built inside the skeleton construction.

I believe it would be a saving if the floor were slotted inside to take movable uprights, in the same way as posts for tennis nets are sometimes slotted into the ground on hard courts. These slots could always be capped so that, when not in use, the floor would be level. They could be designed for calf pens, bull pens, down-calving pens and so forth, also they could be used as slots for uprights to make extra platforms for storage should these be desired. Standardisation of equipment for these could be arrived at similar to that suggested on the dimensions of sheeting, etc., given above. For instance, if beef cattle are being kept, the tractor with dung scoop could go right through the building to remove the winter's depth of dung without being cumbered with low eaves and innumerable bays, etc.

The uses to which such a barn could be put are almost limitless. The milking parlour and dairy could be set at one end if desired or one part could be turned, with great ease, into single or double line cow standings. Stock, fodder and feeding stuffs could all be housed under the same roof as well as implements, grain and fertilisers. If the farmer wished to go



SMALL STOCK BARN BEING BUILT IN WISCONSIN.

The lavish use of timber would not be practical in our country but wider spaced, stronger principals of steel, concrete or laminated wood, could be used direct from the ground as they generally are in larger American barns.

The photograph does, however, show the Gothic arch over the unemcumbered upper floor space.

in for grain drying and storage the building would be equally as well suited for that purpose as for intensive dairying. If grass drying were required it could be done under the same roof. It is possible that we may contrive to dry hay and even grain in most seasons by using an electric fan with cold air occasionally supplemented by hot. For all these purposes such a building could be used. If it is needed as a Dutch barn, then side walls would not be required. At the same time one part of it could be used as a tractor and implement repair depot under cover with easy access. All the many wet weather winter jobs could be done under this shelter. Another point of importance is that a small, but none the less substantial acreage of potatoes will probably continue to be grown on most farms for some years to come, since experience is showing that the best potato land will have to be rested more and more in order to prevent the ravages of disease. There is no job more miserable than riddling potatoes in the open during the winter season, but if the clamp is housed in a corner of the barn this job ceases to be a bogey.

Scientific ventilation of new buildings is clearly a matter for the expert, but no matter how new ventilation systems are devised the working thereof depends in nearly every case on the human element. Most stockmen are traditionally stuffy-minded and can defeat the fresh air hygienists at every turn. Apart from louvre ventilation in the roof, which may not always be satisfactory, there is one system which can give adequate air without draught and which cannot be sealed off. This consists of very small slots at regular intervals in wall and roof through which air, but not rain and storm, can enter. This method of ventilation is well worth the attention of firms building prefabricated wall sheets.

There is one other small point about dairy equipment into which we should enquire. The American system of cooling, which is highly successful, is merely to immerse the ten gallon churn in a shallow water tank, up to the churn's shoulder. Even where these tanks do not have electric coils in them for cooling, results are generally favourable. This saves double handling of milk over our radiator coolers, and thereby reduces the chance of contamination very considerably. Moreover there is none of the difficult washing up and sterilisation of the cooler involved in the immersion system and no waste of water. Provided no more than about ten churns are handled at a time there is very little difficulty in lifting them out of the immersion cooler owing to the balance of weight between the surrounding water and the milk inside the churn. If however, immersion tanks are used for cooling, time for the milk to be cooled must be allowed before collection.

Before concluding this article mention must be made of fodder silos. There is no doubt but that we could grow highly satisfactory crops of hybrid maize. Maize silage is widespread throughout North America and is the mainstay of winter food, but here, unless the whole country simultaneously started to grow maize for this purpose, bird damage at seeding time would render it almost impossible to secure a crop. Apart from those with very specialised experience in growing and harvesting maize silage, I am, therefore, of the opinion that grass and the ordinary English fodder crops will continue to be the materials used by silage growers in England. There is no doubt that good silage is a most valuable food, but a very great deal more development in mechanisation of its collection in the field will have to take place before it becomes a general practice.

Therefore, unless the farmer is an experienced and regular silage maker, the provision of tower silos is a luxury rather than a necessity. Personally I should be inclined to advocate trench silos, wherever the nature of the ground makes these possible, otherwise some form of portable silo would be the most sensible type to use until the practice becomes much more widespread and better mechanised. I have even seen successful silage made in a circular silo of baled straw bound by strong wire ties. Small portable wooden or concrete silos could very easily be introduced under cover in the central barn ; in fact they could be so designed as to be convertible from silage to grain bins or for other storage purposes.

Throughout this essay certain considerations have been implicit, but an explicit warning is necessary. I believe that economists might well be more usefully employed than they sometimes are, if they were to study the relationship between soil productivity and capital cost of fixed equipment on the farm. We are far too inclined to say such and such a building must be necessary for the sake of good estate management, without relating this to what the land can produce while maintaining fertility. For instance what would be reasonable and provident as buildings on an intensive Fenland farm might be pure extravagance on a similar acreage of Bagshot sands. Although this is obvious in the extreme example just quoted, there are very few guides except pure "horse sense" for less sharply marked differences. It is of the utmost importance to have some more detailed studies as a general guide to-day. First, because from now on the State is insisting on good estate management for rural landlord and owner occupier alike; second, because the value of buildings must depend on steady Government policy for English agriculture. Good husbandry and good estate management are not separate departments but two sides of the same agricultural medal. Both depend on the soil's capacity in the last event, but both are at the mercy of Government caprice in agricultural policy. Enforcement of good estate management can only be fair when there is a sound yardstick to guide administration, first in the relationship of fixed equipment to sound production from each individual farm, and, second, in relation to a stable agricultural policy as far as this can be guaranteed. For example need for a packing shed for lettuce must be judged first by the suitability of the surrounding land to grow lettuce, second by the general probability that the lettuce will be marketed at a fair price and not ploughed in because surplus foreign lettuce is dumped in Covent Garden.

PORTSMOUTH.

FARLEIGH HOUSE,
FARLEIGH WALLOP,
BASINGSTOKE.

THE RESIDUAL MANURIAL VALUES OF FERTILIZERS AND FEEDING STUFFS

THE problems involved in studying the residual action of manures with specific reference to the valuation of 'unexhausted improvements' have always been a keen concern of the Royal Agricultural Society. The pages of its Journal have been the medium of publication of most of the major contributions to the technical discussion of the subject, including notably the outstanding contributions first of Lawes & Gilbert, and later of Hall & Voelcker, which laid the foundations of the method of assessment of this particular item that is now widely used in valuations. It is appropriate, therefore, that with the recent opening of a new chapter in the exploration of the subject (Ref. 1) a review should be given here of the evidence upon which the proposed new tables are based, and an indication as to how and why they differ from their forerunners.

A Conference, whose report was issued in May 1946, was convened by the Ministry of Agriculture, at the request of the Central Association of Agricultural Valuers, "to examine the Tables for Residual Manurial Values of Fertilizers and the Manurial Values of Feeding Stuffs, with a view to suggesting any necessary revision of such Tables." Under the chairmanship of Professor Scott Watson the Conference, which included both agricultural chemists and representatives of the Valuers' Association, had the advantage also of discussion with the National Farmers' Union, the Central Landowners' Association, and the Valuers' Association, and its unanimous Report has received the general agreement of these bodies. No such unanimity of support was secured for any previous recommendations and tables.

For the earliest reference in the Journal to the problem of 'unexhausted improvements' one has to go back to its very beginnings. Over a century ago Philip Pusey wrote in Volume 5 of this Journal, "The subject of unexhausted improvements seems to me the most important of all agricultural subjects for landlords at present and the improvement of our agreements in this respect to be a condition *sine qua non* of any steady and general improvement of the soil or its cultivation." The subject was vigorously debated in the 'seventies. In 1870 J. B. Lawes read a paper (Ref. 2) before the London Farmers' Club on "Exhaustion of the soil, in relation to Landlords' Covenants, and the Valuation of unexhausted Improvements," and, at about the same time, the Irish Land Act awarded compensation to an outgoing tenant for "tillages, manures and other like farming works, the benefit of which is unexhausted at the time of the tenant quitting his holding." This led Lawes to preface his first paper on the subject in this Journal (Ref. 3) by the comment that "the Act is very explicit in all that related to the legal machinery by which claims may be tried or established; but it gives no information as to what constitutes unexhausted value, or how that value is to be estimated." In a series of pamphlets (Refs. 4 and 5) and in joint papers with J. H. Gilbert in this Journal (Refs. 6, 7 8) Lawes argued against the old local customs of allowing one-half or even two-thirds of the total expenditure on feeding stuffs in the last year of the tenancy as compensation for unexhausted manurial value. Expensive ingredients, such as soluble carbohydrates and oil, in foodstuffs for animals might have negligible manurial value as foods for plants. "A fundamental principle of the valuation is to take as the original value of the manure *not its cost-price* but its properly ascertained *manure-value*" (Ref. 3). Lawes showed how the results of his feeding trials and field experiments could be used to relate the residual manurial value to the contents of nitrogen, phosphoric acid and

potash in typical samples of the feeding stuff, and he drew up a series of tables showing compensation values over as many as eight seasons. The various tables of Lawes were much discussed, but never widely used in their original form

Soon after the first residual value table was published in this Journal in 1875, it was urged on the Council of the Society that the matters at issue should be settled by direct experiments on different soils and under different conditions. After a full enquiry the Council decided instead to avail itself of an offer of assistance from the Duke of Bedford and to set up an Experimental Station at Woburn under the direction of their consulting chemist (first, A. Voelcker and later, J. A. Voelcker, his son) to test the residual manurial value of corn *versus* cake when fed to animals in the yard or on the land. Later A. D. Hall set up a special experiment on residual values in Little Hoos Field, Rothamsted. J. A. Voelcker and A. D. Hall revised Lawes and Gilbert's tables in 1902 (Ref. 9) and again in 1913 (Ref. 10) and, with a few minor modifications, their tables have remained in fairly general, but by no means universal, use up to the present time. The Royal Agricultural Society, finding itself dissatisfied with the range of actual experimental work available, in 1937 invited the Rothamsted Experimental Station to supplement its residual value experiments on arable land by one on permanent pasture, using the grazing animal itself as the measure of improvement. The results of all these experiments are discussed in outline below.

THE WOBURN EXPERIMENTS.

The story of the Woburn experiments from 1876 to 1933 on the manurial values of cake and corn was told by the late J. A. Voelcker in his joint book with Sir John Russell (Ref. 11). It is a tale of disappointment and disillusionment, illustrating very well both the inherent difficulty of devising sound experimental tests on matters of husbandry and the danger, in the absence of such tests, of relying on convenient rationalisations to support traditional views. Sixteen acres of Stackyard Field were set out in four equal-sized blocks, each to be under the four-course rotation—roots, barley, seeds, wheat—with each crop occupying one block each year. Each block was divided into four one-acre plots. The seeds plots were fed off by sheep, which on Plots 1 and 2 received about 6 cwts. of decorticated cotton cake or maize meal respectively. In the following year plots 3 and 4 received fertilizers roughly equivalent to the cake or maize meal respectively. The root crops received dung made in special boxes by cattle receiving roots and chaff, either with the addition of 1,000 lb. of cake or maize meal on Plots 1 and 2 or without addition on Plots 3 and 4. Roughly equivalent amounts of fertilizers were given to the roots and the following barley on Plots 3 and 4.

TABLE I.

Average annual yields per acre Stackyard Field, Woburn 1877-85.

Manuring	Roots: Mangolds tons	Roots: Swedes tons	Barley bushels	Seeds lb. Live-weight increase of 10 sheep	Wheat bushels
Dung from					
Maize meal	11.8	17.0	45.8	356	41.8
Cotton cake	12.6	17.3	46.3	362	40.7
Fertilizers equivalent to					
Maize meal	13.0	18.2	43.3	250	41.6
Cotton cake	16.6	19.8	48.7	248	40.3

When the experiment began decorticated cotton cake cost £6 10s. per ton and maize meal £1 11s. per ton but the cake dung applied to roots gave practically no greater yield than the maize dung, in spite of its additional nitrogen, nor was there any difference in the following barley. The fertilizers were superior to the dungs, the cake-equivalent being

better than the maize-equivalent. The sheep naturally gained more weight as the result of receiving cake or corn, but the following wheat crop showed no difference in manurial value between these two foods and no advantage of feeding-stuff residues over fertilizers.

This failure to bring out the expected differences led to a number of changes in the design of the experiment. It was supposed that the land might already be giving its maximum crops. The manuring was therefore continued with cake and corn on a much reduced scale, no dung being applied to the roots and no cake or corn being fed with the seeds. Instead, a fraction of the roots was fed off with 400 lb. cotton cake or maize meal per acre on the appropriate plots and their fertilizer equivalents given to the other. Only the barley crop immediately following the manuring showed any advantage of cake over corn, and once more, fertilizers equivalent to the cake gave still higher yields. After several more changes a review of the whole of the results forced J. A. Voelcker to the conclusion that the experiments had entirely failed to show any marked superiority of cake-feeding over corn-feeding on this soil. The extra nitrogen in the urine or the dung from cake-feeding had been lost in some way—probably largely by leaching from the soil—before the following crops could utilise it properly.

THE ROTHAMSTED EXPERIMENTS.

a. Little Hoos Field.

This experiment was laid out in 1904 by A. D. Hall to test a number of points which had arisen during the compilation of the first set of Voelcker and Hall tables and also to prepare the way for treating the residual value of fertilizers. A preliminary account of the results was published in this Journal in 1913 (Ref. 12) immediately after a second paper by Voelcker and Hall (Ref. 10) giving revised tables, which, for the first time, included recommendations for the residual values of fertilizers. The experiment was continued until 1926, and a fuller summary of the results was given in 1940 by D. J. Finney (Ref. 13), who had, however, to warn his readers against placing too great a faith in the inferences he had drawn from the results. Once again, systematic lay-out of the plots and frequent changes in the manuring and cropping systems had made it impossible to apply objective statistical tests to the data.

Some comment on the design of this experiment is called for, because it illustrates some of the difficulties inherent in measuring residual effects. Hall rightly broke away from the orthodox method of applying the manures at a definite point in the crop rotation. He aimed to measure all stages of exhaustion under the same conditions by using the same test crop. Unfortunately he could use only a single crop each year and, at that time, the need for replication and randomisation was not appreciated. The experimental area had 40 plots, each of 1/8th acre, in eight parallel strips, one for each material tested. Each strip had five plots of which one never received the manure and (after the preliminary years) the other four gave contrasts between the immediate effect and the residual effects after one, two and three years. The experiment had a regular pattern so that natural differences in soil fertility running parallel with the strips appeared as differences between manures, and those running at right angles appeared as differences between years of application. There was no means of estimating the extent of these irregularities. Further, as both manuring and cropping were planned to run on four-course rotations, a given treatment of a given crop would continue to recur on a given plot of land however long the experiment lasted.

The strips were in two series: one for dung and nitrogen manures, in which all plots including "controls" received additional phosphate and potash, and one for phosphate manures, in which all plots including "controls" received additional nitrogen and potash. In Finney's paper, which must be consulted for details, the responses to dung or fertilizers after 0, 1, 2 and 3 seasons are measured by the crop increases over the average of the

appropriate stationary "controls." An alternative treatment is to ignore the "controls" and to use instead the plots with residues after three years. This smooths out some of the more permanent soil irregularities because all the treated plots in each strip then serve in turn as "control"—but it runs the risk of missing some long-term residual values. The average results are summarised by both methods in Table 2 for the effects of three nitrogen fertilizers and three phosphate fertilizers and for the average superiority of cake-fed over corn-fed dung.

TABLE 2.

Residual value effects in Little Hoos Field Experiment, Rothamsted, 1907-1922.
Nitrogen fertilizers = shoddy, guano, rape-dust
Phosphate fertilizers = superphosphate, bone meal, basic slag.

	Years since manuring	Roots, tons per acre (4 cycles)	Barley bushels per acre (3 cycles)	Wheat bushels per acre (4 cycles)
Nitrogen fertilizers				
minus no nitrogen	0	2.2	14 1	4.9
	1	0.9	0.8	1.5
	2	0 4	0.8	0.9
	3	-0.6	0 9	0 1
Nitrogen fertilizers				
minus third year residues	0	2 8	15.0	4.8
	1	1.5	1.7	1.4
	2	1.0	0 0	0.8
Phosphate fertilizers				
minus no phosphate	0	2.5	9 0	1.5
	1	2.8	3.1	2.0
	2	1.8	2.1	1.4
	3	1 3	2.9	1 4
Phosphate fertilizers				
minus third year residues	0	1.2	6.1	0.1
	1	1.5	0.2	0.6
	2	0.5	0.8	0.0
Cake-fed dung				
minus ordinary dung	0	1.0	4.0	4.0
	1	1.2	2 3	3.2
	2	0.0	2.4	-0.4
	3	0.4	2.7	0.2

Organic nitrogen fertilizers (shoddy, guano and rape dust) showed clear effects in the year of application with almost negligible residual effects. (Detailed figures not presented here showed somewhat higher yields from residues of shoddy at all periods, but this may have been due to intrinsic differences in soil fertility between the strips).

Phosphate fertilizers showed both immediate and one-year residual effects on roots, immediate but no residual effects on barley and no effect, either immediate or residual, on wheat, apart from some slight superiority over the three plots without phosphate, which may have been the result of soil irregularity.

The benefit from cake-fed over corn-fed manure showed clearly in the year of application and for one year after application, but there was no clear evidence in any crop of any residual value after two or three seasons.

b. Hoos Field Four-Course Rotation.

This experiment was started in 1930 on a four-course rotation with one block for each crop each year. Each block had 25 plots and different experimental manurial treatments were given to five plots in any one year and repeated on the same plots every fifth year. The combination of a four-course cropping rotation with a five-course manuring rotation means that, for each material tested, the combination of a given crop and a given stage of exhaustion recurs only once in 20 years. By this time each one of the 20 plots for each manure will have been used to test each stage of exhaustion on every crop. The effects of soil irregularities will thus be reduced to a minimum.

The experiment falls into two sections. The first tests three bulky organic manures—farmyard manure, straw-compost, and raw straw. The farmyard manure and straw compost supply equal amounts of organic matter, and the raw straw is equal in amount to that used in making the compost. Each manure is analysed shortly before application, and extra fertilizers are added to provide equal total amounts of nitrogen, phosphoric acid and potash in all three treatments. No further fertilizer is given in the next four seasons. The second section has two treatments—superphosphate and mineral phosphate—applied once in five years with the same total amount of phosphoric acid as in the adjusted organic manures, but with *annual applications* of nitrogen and potash equal to one-fifth of the total amounts used in the organic manure series. The superphosphate series thus tests five-yearly phosphate with annual nitrogen and potash against equal total amounts of plant foods in organic manures applied every five years. The experiment should show in time whether the omission of organic manures has any cumulative effect. Mineral phosphate is known to be unsuited for this neutral soil, but it was included to serve as a " control " in the early years and also to test whether or not it might exert any progressively beneficial effect over a long period.

Data for each stage of exhaustion are already available in twelve seasons for potatoes, barley and wheat and in ten seasons only for rye grass. A concise summary of a few of the main results are given in Table 3.

TABLE 3.

Residual Effects in Hoos Field Four-Course Rotation Experiment, Rothamsted, 1932 to 1945.

The dung and straw-compost each supplied 50 cwts. organic matter per acre. The raw straw equalled the amount used to make the compost. Fertilizers were added to raise the total plant foods to 1.8 cwt. N, 1.2 cwt. P_2O_5 and 3.0 cwts. K_2O per acre. These manures were applied every five years with nothing in the four intervening seasons.

The superphosphate and mineral phosphate supplied 1.2 cwts. P_2O_5 per acre every fifth year with 0.36 cwt. N and 0.6 cwt. K_2O as sulphate of ammonia and muriate of potash every year.

	Years after Application	Potatoes tons per acre	Barley cwt. grain per acre	Rye grass cwts. dry matter per acre	Wheat cwts. grass per acre
Organic Manure Series					
Farmyard manure .	0	6.0	27.9	18.9	21.5
,, ,, ...	1	4.9	23.5	12.5	17.8
,, ,, .	2	4.7	20.4	10.3	16.1
,, ,, ...	3	4.4	19.3	9.6	15.8
,, ,, ...	4	4.3	18.8	8.9	15.0
Yields in year of application					
Farmyard manure ...	0	6.0	27.9	18.9	21.5
Straw compost ...	0	5.6	27.8	18.1	21.6
Straw + fertilizers ..	0	6.8	30.0	30.6	24.6
Average yields from residues. (without additional fertilizers)					
Farmyard manure	Mean 1-4	4.6	20.0	10.3	16.2
Straw compost	,, 1-4	4.0	20.0	10.3	16.0
Straw + fertilizers	,, 1-4	4.6	21.4	11.1	16.5
Phosphate series (with nitrogen & potash annually)					
Superphosphate	0	6.5	28.4	18.1	19.3
,, ...	1	5.2	27.5	19.4	18.7
,, ...	2	5.6	27.1	18.8	19.1
,, ...	3	5.5	27.4	16.8	19.1
,, ...	4	5.2	26.7	17.2	19.3
Superphosphate ...	0	6.5	28.4	18.1	19.3
,,	Mean 1-4	5.4	27.2	18.0	19.0
Mineral phosphate ...	0	4.3	23.5	16.4	18.5
,, ,,	Mean 1-4	4.3	25.4	16.1	19.2

The benefits from farmyard manure were very much less after one year than in the year of application, and there was a small but steady decline up to four years after application. In the year of application raw straw with fertilizers gave better results than farmyard manure or straw composts, the advantage being especially great with rye-grass, which responded very well to the large amount of sulphate of ammonia given with the straw. The average residual effects from raw straw with fertilizers were at least equal to those from farmyard manure. Farmyard manure gave better results than straw-compost on potatoes, both immediately and as residues; these two manures gave equal yields for the other crops. Raw straw with fertilizers gave far better results than straw-compost, though the differences in residual effects were small for cereals and rye-grass.

The plots with superphosphate every five years and one-fifth of the total nitrogen and potash given each year gave yields similar to farmyard manure in the year of application. This suggests that only about one-fifth of the nitrogen in farmyard manure is immediately available. In residual effects these fertilizer plots were far superior to the residues of farmyard manure at all stages, because the annual application of nitrogen and potash supplied much more available plant food than the residues from the organic manures.

The superphosphate plots brought out a most important general point in connection with the residual value of fertilizers. The yield of potatoes immediately after application was over 1 ton per acre more than from residues at any stage, but the value of the residues fell off only very slowly, if at all, from the first to the fifth year. Since mineral phosphate gave the same immediate and residual effects it may be assumed that this form of phosphate has so far been practically ineffective. If mineral phosphate is treated as a "control," it follows that superphosphate has a considerable and prolonged residual effect, since its residues give one ton more potatoes per acre than the residues of mineral phosphate for each of the five years. The high immediate effect of superphosphate on potatoes clearly depends in part on the circumstance that it is applied in bouts at the time and in the place where it can act most quickly on the young crop. This is an excellent form of "fertilizer placement." All residues from previous crops are necessarily much less efficient, because the intervening ploughing dissipates them through a large mass of soil and leaves no local concentration near the sets. This result must be expected in all soils, but in many there is the additional rapid wastage through so-called "phosphate fixation" or the formation of inert and useless residues in the soil.

It will be noted that the wheat showed no trace of response to superphosphate, and the barley and rye-grass only modest ones. This is fully in accord with the results of all published experiments on cereals on old arable land in the south and east of England, as summarised by E. M. Crowther and F. Yates (Ref. 14). It illustrates very clearly a most important aspect of residual values, which is commonly overlooked. The experienced farmer uses phosphate on the crops which most need it—swedes, seeds, potatoes, etc.—and these crops are normally followed by cereals, which have little capacity for utilising the phosphate residues, unless the soil is already very deficient in available phosphate.

c. Grazing Experiment in High Field.

Since 1937 an experiment on 9 plots, each of 5 acres, of permanent grassland has been carried out at the request of the Royal Agricultural Society, to assess the residual value of cake fed to cattle. The productivity of pasture on which cattle have been cake-fed is compared in the following two years with that of pasture receiving fertilizers applied at rates equivalent to the estimated residual value of the cake, as given in Voelcker and Hall's 1913 Tables (half the nitrogen and three-quarters the phosphoric acid and potash), and with that of pasture receiving neither cake nor fertilizer. The productivity is estimated from the maintenance requirements and live-weight increases of stock (cattle and sheep in a fixed ratio) grazing on the plots in the two years after cake-feeding. The results summarised in

Table 4 show that very similar returns in starch equivalent have been obtained from the residues of the cake-feeding and from their assumed fertilizer equivalent. The benefit from both cake and fertilizers showed in the first year after feeding or manuring, but were very small in the second year.

TABLE 4.

Grazing experiment, High Field, Rothamsted 1937-1945.

	No treatment	Cake-fed	Equivalent fertilizers
Live-weight increase, lb. per acre.			
1st year after cake-feeding			
Cattle ...	196	253	240
Sheep ...	88	92	93
2nd year after cake-feeding			
Cattle .	210	232	196
Sheep ...	85	69	82
Starch equivalent, cwt. per acre			
1st year after cake-feeding (1)	13.9	15.8	16.0
2nd year after cake-feeding (2)	14.4	14.9	14.6
Increase in two years over no treatment .	—	+2.4	+2.3

(1) *Mean of 8 seasons.* (2) *Mean of 6 seasons.*

No clear evidence has been obtained of any build-up in fertility due to the heavier stocking possible where cake is fed.

This is probably the first experiment in which the residual benefits from cake-feeding have been successfully measured through grazing animals. It shows that the Voelcker and Hall tables were of the right order for foodstuffs consumed on grassland.

THE EARLIER RESIDUAL VALUE TABLES.

A brief review of the principal residual value tables will show the general development, the changing emphasis and the need for further revision. In their final tables (Refs. 7 and 8) for feeding stuffs Lawes and Gilbert allowed for the small amounts of plant nutrients retained by the animal as fattening increase (up to 15 per cent. for nitrogen, 20 per cent. for phosphoric acid and 3 per cent. for potash) and charged the rest as "total or original manure value per ton of food consumed," taking unit prices in fertilizers. (The unit price is the cost of 1/100th part of 1 ton). For all foods but hay and straw they took one-half of the original manure value of the food as the compensation value in the last year, and deducted one-third of the remainder for each previous year up to the eighth before the end of tenancy. For hay and straw they deducted two-thirds of the original manure value for the last year and only one-fourth for each previous year up to eight. Thus, the compensation value for linseed cake fed to fattening animals was 26s. 0d. per ton in the last year of tenancy and 1s. 6d. seven years previously. For wheat straw corresponding figures were 6s. 0d. and 6d. respectively. Further deductions were made for foodstuffs fed to cows, according to the milk yield.

The Lawes and Gilbert tables were too detailed and complicated to be serviceable and were therefore simplified in 1902 by Voelcker and Hall, who assumed that half of the nitrogen, three-quarters of the phosphoric acid and all the potash reached the manure, and valued these amounts at unit prices based on the average of a number of organic and inorganic fertilizers. The full allowance so calculated was made for all foodstuffs purchased in the last year of tenancy, and one-half, one-quarter and one-eighth for those consumed in the last year but one, two, and three respectively. When Voelcker and Hall revised their tables in 1913 they reduced to three-quarters the fraction of potash taken as reaching the dung, increased the unit value of nitrogen to allow for changes in fertilizer prices, allowed 70 per cent. of the total manurial constituents for food stuffs consumed on grassland in the last year of tenancy only, and cut down the period of compensation to two periods—before and after one crop had been grown or removed.

Voelcker and Hall also included for the first time tables for estimating the residual values of fertilizers and liming materials, pointing out, however, that the influence of fertilizers must depend not only upon their suitability for the particular purpose for which they were employed, but also upon the condition of the land, and whether they had been rightly applied. It was also emphasised that it was impossible to discriminate between the residues left by different crops. "The decisive factor is less the withdrawal by the crop than the changes which afterwards go on in the soil." The allowances were on a cost basis, various fractions being taken according to the conditions and the interval since manuring. Thus basic slag and superphosphate were valued at two-thirds, one-third and one-ninth cost after one, two, and three arable crops, but basic slag was valued on an eight-year principle on grassland (*i.e.*, one-eighth of the cost was subtracted each year). Compound fertilizers were valued at one-third and one-sixth after one and two crops. Nothing was allowed for the residual effect of quickly acting nitrogen fertilizers. Lime was valued on a six-year principle on arable land and an eight-year principle on grass.

The Voelcker and Hall Tables were reissued by the Central Association of Agricultural Valuers in 1939, with a number of minor changes. It was assumed that 45 per cent. of the nitrogen reached the dung. The valuation for lime was more drastically changed. Dressings to 1 ton per acre were allowed at one-half and one-quarter after the first and second crops ; larger dressings were treated as losing 4 cwt. calcium oxide per acre per annum and the remainder valued at cost up to a total of ten years. Later, a 25 per cent. increase was added to all compensation values to cover wartime changes.

Between the second and third revisions of Voelcker and Hall's Tables there were a number of alternative proposals. Dr. C. Crowther in 1913 (Ref. 16) and a Scottish Committee in 1917 laid special emphasis on the distinction between the fates of digestible and indigestible nitrogen. All the digestible nitrogen and about 85% of the potash—together accounting for about 80 per cent. of the manurial value—passed into the urine, whilst the indigestible nitrogen and all the phosphate went into the faeces. The value of the resulting manure depends essentially on the extent to which the urine is conserved and used. Too often it is lost down the drains and the compensation value ascribed to the manure may be fictitious. The Highland and Agricultural Society tried a method of valuation based on distinguishing digestible from indigestible nutrients in the single year 1938.

In 1927 a Committee composed of the leading agricultural chemists of Great Britain re-examined the whole basis of valuation, and a Joint Committee of chemists and representatives of the various professional bodies considered how the recommendation of the Scientific Committee could best be adopted in practice (Ref. 17). The Scientific Committee proposed a number of reductions on Voelcker and Hall's Tables. They suggested that only 40 per cent. of the nitrogen should be assumed to reach the manure, that a lower unit price be used for phosphoric acid in feeding stuffs, that a large reduction be made for feeding stuffs fed either to dairy cattle or to all stock on grass, and that the reduction after taking one crop should be to one-third in place of to one-half. The Joint Committee did not, however, agree to the distinction between foodstuffs consumed on grass and in yards or to such large reductions for those fed to dairy cows. Many of the 1927 recommendations were accepted by the Department of Agriculture for Scotland, which frequently reprinted the two Reports and issued revised tables, with a few additional changes (Ref. 18). In England and Wales both reports were rejected by the professional bodies concerned, and no steps were taken to implement the general recommendation that a Standing Committee should undertake frequent revision of the tables.

Table 5 below has been drawn up to summarise the various estimates of the manurial values of plant nutrients in feeding stuffs in comparison with the current prices of the same nutrients in fertilizers.

TABLE 5.

Values ascribed to plant foods in purchased feeding stuffs as percentages of those in standard fertilizers.

(The manurial values are residues used as dung before one crop has been grown).

	Year	N	P_2O_5	K_2O
Lawes and Gilbert	1897	38	51	40
Voelcker and Hall	1902	51	54	114
,, ,, ,, ...	1913	59	51	84
Joint Committee	1927	47	78	79
Scottish Committee	1940	51	82	100
Central Association	1944	60	47	72
Highland Society	1944	40	75	75

In 1944 the Highland and Agricultural Society allowed 3/11 and 4/4 per unit of nitrogen and phosphoric acid respectively in feeding stuffs, whereas the Central Association of Agricultural Valuers allowed 5/8 and 2/10 respectively, *i.e.*, much more for nitrogen and much less for phosphoric acid. The Highland and Agricultural Society also continued allowances after two crops had been grown. One potent factor leading to the discrepancies shown in Table 5 was the lack of any clear convention about the unit values to be used for the plant foods, even when there was some measure of agreement on the average proportions of the plant foods assumed to reach the manure.

SOME GENERAL CONSIDERATIONS.

The study of the residual and cumulative effects of manures, cultivations and crop rotations on the maintenance and improvement of soil fertility is of vital importance to the advancement of husbandry, and is rightly the main preoccupation of research workers in soil science and general agriculture. Their work may be expected to continue to throw fresh light on the problems confronting the agricultural valuer, whose task, however, lies within much narrower and more rigidly defined limits. As these are sometimes not fully appreciated by the parties most immediately concerned in a change of tenancy, it is worth while reproducing the essential sentences of the Agricultural Holdings Act 1923 (13 and 14 Geo. 5., Ch. 9.).

> "Where a tenant of a holding has made thereon any improvement comprised in the First Schedule to this Act, he shall be entitled, at the termination of the tenancy, on quitting his holding to obtain from the landlord as compensation for the improvement such sum as fairly represents the value of the improvement to an incoming tenant."
>
> The First Schedule includes under Part III "*Improvements in respect of which Consent of or Notice to Landlord is not required.*
>
> (20), (23) and (24) Chalking, liming or marling of land, (25) Application to land of purchased artificial or other purchased manure.
>
> (26) and (27) Consumption on the holding by cattle, sheep, or pigs, or by horses other than those regularly employed on the holding, of (26) corn, cake, or other feeding stuffs not produced on the holding or of (27) corn proved by satisfactory evidence to have been produced and consumed on the holding."

It is immaterial how much the outgoing tenant may have expended on a particular operation, the valuer must estimate only its value to an incoming tenant. This immediately imposes many restrictions. Thus, where an arable field is left in such a weedy condition that it must be fallowed for cleaning, the tenant is unable in that year to derive any benefit from the manurial residues which might otherwise have been available in that field. In the extreme case of a small all-grass farm with heavy purchases of foodstuffs for a large number of dairy cows, the customary valuation for feeding stuffs must be drastically written down, because an incoming tenant would be unable to recover the full value of the compensation in the

form of increased crops. Again, compensation should be drastically reduced if an outgoing tenant has applied heavy dressings of liming materials to land not in need of lime, or if he has used unnecessarily expensive forms.

Any set of general recommendations and illustrative tables can only serve as a general guide to the valuer and should not be applied rigidly. The valuer's main task in dealing with manurial residues is to understand the fate and behaviour of plant foods in the feeding shed and in the soil, and not merely to indulge in an elaborate exercise of chemical arithmetic and accountancy. Equally, in dealing with manurial residues he must not overload his treatment by superimposing a set of rules or customs intended to define good husbandry. Thus, he should not adjust the residual values according to the particular crops grown during the last years of the tenancy, on the grounds that certain crops are more "exhausting" than others. The amounts of phosphate and potash removed by potatoes and swedes are greater than those removed by cereals, but it is unnecessary to reduce the compensation since the amounts of these plant foods actually removed in the crops are often small by comparison with those locked up in unavailable forms in the soils.

The removal by crops is amply covered by the allowances in the tables and the differences between crops are of minor importance by comparison with the differences between soils, both in their responsiveness to fertilizers and in their ability to retain added plant foods in available forms. It has sometimes been suggested that one way out of this difficulty would be to have detailed soil analyses of each field at a change of tenancy. Although this might be done with sufficient accuracy for lime, it is doubtful whether the necessary precision could be obtained for phosphate and potash. In any event the cost of the field sampling and the laboratory investigations would be quite out of proportion to the value of the results. Soil analyses should be used as the basis of advisory work on future practice and not for trying to recover past expenditure.

It is well established by careful experiment and by practical experience that most nitrogen fertilizers have little residual effect in the following year. Whatever form is added, the bulk of any residue is washed out as nitrate during the winter in the humid temperate climate of Great Britain. There is, of course, the indirect benefit that on many farms more nitrogen fertilizer means more fodder and straw, and therefore more farmyard manure. Against this, the bigger crops grown with nitrogen fertilizers must remove more of other plant foods, but this effect is relatively small, and no more serious than the extra "exhaustion" caused by other methods of growing bigger crops, as by better cultivation or better varieties.

Phosphates and potash behave quite differently from nitrogen. The usual residues are not washed out, but, none the less, they may rapidly lose their availability by going over into inert forms within the soil. Phosphates become useless particularly rapidly on very acid soils and on some calcareous soils. This is the reason why so much of the old grassland ploughed-out during the war was unproductive until phosphates were given. It also explains why on such soils phosphates have to be given for every root and seeds crop, and even for cereals. Indeed, on such soils an increasing number of farmers are finding that it pays not only to give the usual dressings of phosphate to the roots and seeds but to give a small dressing to all their cereals through a combined fertilizer seed-drill. They are rightly adopting the policy of "little and often" instead of relying on residual effects.

On neutral or only slightly acid soils, on the other hand, phosphates may have a prolonged residual effect, and additional phosphate will generally be quite unnecessary for cereal crops following an occasional root crop receiving phosphate. This was illustrated in the Rothamsted experiments already described. It was brought out too in the wartime experience of occupied countries, such as Holland, Belgium and Denmark, which had used lime and fertilizers heavily and well before the war. It was found—often to the surprise of

the farmers—that good crops could be grown for several years with little or no more phosphate. The greater residual value of phosphates in nearly neutral soils is one of the important indirect benefits of liming.

Phosphate fertilizers act best when placed fairly close to the seed so that they may at once exert their stimulating effect on the early root growth of the young plant. It is for this reason that potato fertilizers are generally placed in the bouts, swedes sown on ridges split back over manure, or cereals drilled with phosphate. The young roots soon pass into pockets of soil rich in available phosphate and absorb it rapidly. Many crops can absorb enough phosphate in a few weeks to carry them through to maturity. Ploughing necessarily dissipates the phosphate residues through a large mass of soil and the next crop must start in a less rich medium. Even in soils capable of retaining available phosphate for years the residual effects must fall rapidly after the first year and then more slowly, as was shown very clearly in the potato crop of the Rothamsted four-course rotation. The residual value necessarily falls off more rapidly in acid soils and in other soils with high " fixing " powers. Potash shows the effects of fixation to less available forms and the benefit from localised placement in much the same way as phosphate, though to a smaller extent. It is reasonable therefore, to treat phosphate and potash similarly, but to allow less prolonged residual effects for potash, because crops remove larger proportions of potash than of phosphate.

It is not feasible to allow for the different durations of residual effects on the vast variety of soils, and the 1946 Committee decided to allow potash over two growing seasons and phosphate over three, and in all cases to halve the residual value after each season. This is frankly a compromise solution. Although the actual residual value may fall off rapidly at first and then more slowly, the values proposed for two or three years will probably give a fair picture of the average treatment of the whole of a farm over many years. Not many farmers will manure much more heavily with phosphate and potash in the last two or three years of their tenancy merely to increase their tenant-right.

Lime is lost from the soil almost entirely by leaching in drainage water. The rate of loss is increased by ammonium salts and by the acid rainwater of industrial areas, and slightly reduced by nitrate fertilizers, but it also varies widely from soil to soil. The loss is naturally slow in very acid soils containing little lime in the exchangeable form with none in the reserve form of carbonate. When small amounts of lime are added to such soils the annual loss of lime is still small: larger dressings, which raise the soil towards the neutral point, inevitably increase the rate at which lime is lost. Acid-tolerant crops may be grown with very occasional liming on moderately acid soils, and even small dressings of lime show their effects for many years. Where, however, sufficient lime is used to allow a wider range of crops and balanced farming, it is necessary to resort to frequent liming to maintain soil fertility at the higher level. These differences are well illustrated by the Woburn continuous wheat and barley plots which had been rendered acutely acid by repeated dressings of sulphate of ammonia. Various dressings of lime were given to sub-plots, and, twenty years later, these were found to contain the amounts of exchangeable lime shown in Table 6 (Ref. 19).

TABLE 6.

Amounts of exchangeable lime, Stackyard Field, Woburn, 1927.

Fertilizers	No nitrogen	Sulphate of ammonia		
Liming	None	None	Light	Heavy
Exchangeable lime, tons per acre				
0 to 9 inches	1.80	0.57	1.14	1.97
0 to 18 inches	3.91	2.37	3.35	4.20
Total lime in tons per acre 0 to 18 inches				
Total amount added	—	—	1.36	2.64
Remaining in soil	—	—	0.98	1.83
Lost from soil	—	—	0.38	0.81

The total loss of lime was twice as great from the heavily limed as from the lightly limed plots. Nearly three-quarters of the lime remained from the light dressings. Unfortunately it is not possible from these figures to answer the question " How long does lime last in the soil ?" The rate must necessarily have been high soon after application and have fallen in the later years, when all plots had again become acid. Although if land is allowed to run out, and become quite acid, former liming may exert some slight benefit for ten or twenty years, this ultimate residual value is of relatively little practical value. The practical aim should be to hold the reaction of the soil at a steady value only slightly on the acid side. A compromise must therefore be found between extremes, and the 1946 Conference has recommended that lime be valued on an eight-year principle.

The early tables of Lawes and Gilbert and of Voelcker and Hall were devoted entirely to the residual value of purchased feeding stuffs. The 1946 Report devotes more space to fertilizers than to feeding stuffs. This is as it should be, because there has been very great progress in recent years in both scientific and practical knowledge on the use of fertilizers. The emphasis on feeding stuffs has shifted. They are now selected and used on their merits for their proper purpose of feeding stock and maintaining the balance of the farm and not mainly for their indirect value in feeding the soil. Even those farmers who may be disposed to dispute this statement on theoretical grounds will probably illustrate its truth by the way in which they actually handle the liquid and solid manures on their farms. Seventy years ago, when residual values were first seriously debated, purchased feeding stuffs provided the only generally feasible way of obtaining additional ammonia for crops, and in many parts of the country the common systems of farming were based on feeding bullocks in boxes or folding sheep on arable land. The method worked admirably so long as abundant supplies of cheap labour and cheap imported animal foodstuffs were forthcoming. It was not always appreciated that the proper conservation of ammonia and potash was a vital link between the stock, the land and the crops. As bullocks and sheep gave way to cows and the arable land to grass, less and less attention was paid to the conservation of urine, and the old liquid manure tanks fell into disuse.

Farmers in general appear to have taken little notice of the striking results of the Woburn and Rothamsted experiments on cake-fed versus corn-fed manure, perhaps because there were too few such experiments to build up general confidence or to afford convincing local demonstrations. The position was quite different in Denmark, where a series of long-term field experiments and associated laboratory work showed that to obtain the full benefit from the foodstuffs fed to dairy cows it was necessary to store the liquid manure most carefully and use it directly on the land. In Denmark heavy Government subsidies have been used to install, enlarge and recondition liquid manure tanks, until now almost every Danish farm has a liquid manure tank in active use. Some 20,000 special liquid manure drills with cultivator tines are employed to place the liquid manure below the soil surface ahead of spring sowings. In this way the nitrogen and potash are used directly and most efficiently, whilst the dung loses little of its other important values. There is still sufficient ammonia to rot it properly without the wastage of ammonia which occurs when dung is used as the sole carrier of plant foods. All modern work has confirmed the results of the old experiments which showed that a large proportion of the ammonia taken up by rotting straw in farmyard manure or compost fails to become available to crops, and that the small remaining amount of free ammonia or readily available nitrogen in dung is both liable to loss by exposure and relatively transient in its effects on crops. To emphasise the difficulty of recovering the full benefit of the extra ammonia and potash added to farmyard manure from purchased feeding stuffs is not, of course, to dispute the intrinsic merits of farmyard manure ; these would often not be greatly impaired had less purchased food been used, and it is only the additional value from the purchased foods that is eligible for compensation. The 1946

Report therefore puts in the forefront of its treatment of the residual manurial value of feeding stuffs an assessment of the effects of the whole system of farm management on the recovery and utilisation of the manure. It differs from the Voelcker and Hall 1913 tables in setting out *compensation values for average conditions*, and then suggesting fractions by which these should be *increased or reduced* according to the general conditions on the farm. Less compensation is allowed for foodstuffs fed to milking cows, to cover the loss of plant foods in milk and the common wastage of urine. Foodstuffs fed on the land and in covered yards are ranked equally high, and deductions are made for feeding in open yards, owing to inevitably higher losses. As in Voelcker and Hall's 1913 tables the compensation value is halved after one crop has been removed. The unit period is determined by the crop instead of by the growing season or the time before the end of the tenancy because it is often good practice to make manure during the early winter and cart it out for root crops in the following spring. In this way much of the manurial value is recovered within less than a year after the foodstuff is consumed.

✓SUMMARY OF THE 1946 REPORT.

The Report must be consulted for all the essential definitions, recommendations and illustrative tables. Here it is possible to give for reference only a brief summary of the principal recommendations (Ref. 20).

All valuations are to be based on the actual composition of the fertilizer or feeding stuff, as shown in the statutory warranties provided on the invoices. The percentages of nitrogen, phosphoric acid and potash are to be multiplied by appropriate unit prices. These unit prices have been related to rounded unit prices of the standard fertilizers, and suggestions are made as to how the various unit prices are to be adjusted if and when fertilizer prices change substantially. When this is necessary the Central Association of Agricultural Valuers will issue a completely revised series of tables. The current tables have been related to the following rounded unit prices in fertilizers: nitrogen (N) 10s. 0d., phosphoric acid (P_2O_5) 6s. 0d., potash (K_2O) 5s. 0d.

Fertilizers.

Fertilizers are classified according to their availability and the average duration of their effects, and then valued by using the appropriate unit prices in Table 7.

TABLE 7.

Compensation values for the residual effects of unit plant food in fertilizers.
(*i.e.*, price for each 1 per cent. of a ton).

	After 1 growing season s. d.	After 2 growing seasons s. d.	After 3 growing seasons s. d.
Nitrogen			
(*a*) Inorganic (as in sulphate of ammonia, compound fertilizers) ...	*nil*	*nil*	*nil*
(*b*) In dried blood ...	*nil*	*nil*	*nil*
(*c*) In all other organic forms specified in the First Schedule of the Fertilizer and Feeding Stuffs Act (*e.g.*, hoof, meat, bone)	5 0	2 6	*nil*
Phosphoric Acid			
(*d*) Soluble by official methods (as in superphosphate, basic slag) ..	4 0	2 0	1 0
(*e*) Insoluble by official methods ...	2 0	1 0	6
(*f*) Total (or insoluble) in bone products ...	3 0	1 6	9
(*g*) Total in other materials (*e.g.*, mineral phosphate ...	2 0	1 0	6
Potash			
(*h*) Total	2 6	1 3	*nil*

Lime and Limestone.

All compensations are based on delivered costs after the recovery of subsidies. Compensation is paid on an eight-year principle *i.e.*, one-eighth is subtracted each year after application. The full delivered cost (less subsidy) is taken as the basis for compensation where the liming was done at moderate rates or in accordance with recommendations by the National Advisory Service. But where a farmer has used heavy rates or unduly expensive forms without such advice, dressings containing more of any form of lime than the equivalent of 40 cwt. pure calcium oxide (CaO) per acre is to be valued at the cost (less subsidy) of this quantity as either burnt lime or ground limestone, according to the form used.

Feeding Stuffs.

The average compensation values worked out from the appropriate unit prices given below are subject to the adjustments listed in Table 8 according to the conditions under which the foodstuffs are fed, the urine conserved and the farmyard manure made, stored and used.

Conditions are to be regarded as satisfactory where the urine is well conserved and the dung well made, where reasonable precautions are taken against losses in the dung heap, and where the dung is applied to land to give likely responses.

TABLE 8.

Adjustment of average compensation values to various conditions.

	Foodstuffs fed to milking cows	*Foodstuffs fed to stock other than milking cows and working horses*
(1) Fed directly on the land	average	add one-third
(2) Fed under cover—conditions satisfactory	average	add one-third
(3) Fed in open yards—conditions satisfactory	subtract one-third	average
(4) Conditions unsatisfactory	subtract up to two-thirds	subtract up to one-half

For the average conditions the unit prices in the original foodstuffs are given in Table 9.

TABLE 9.

Average compensation values for the residual effect of unit plant food in fertilizers (i.e., price of each 1 per cent. of a ton.

	Before one crop has been removed *s.*	*d.*	after one crop has been removed *s.*	*d.*
Nitrogen	3	0	1	6
Phosphoric Acid	3	0	1	6
Potash	3	0	1	6
Incompound cakes and meals				
Albuminoids (proteins)		10		5

Compound cakes and meals are treated separately because warranties do not normally declare the percentages of phosphoric acid and potash. Allowing 10d. per unit of protein is equivalent to valuing nitrogen at 5s. 2d. per unit and ignoring the phosphoric acid and potash. For the ordinary cakes and cereal grains this gives sufficiently close results to valuing each of the three plant foods at 3s. 0d. per unit.

Straw and other bulky materials.

For straw and other bulky manures, such as pea and bean straw, bracken and peat, an allowance may be made for the combined nutrient and mechanical values of 12s. 0d. per ton before one crop has been removed and of 6s. 0d. per ton after one crop has been removed. Where straw has been sold off the farm a dilapidation may be made at the rate of 12s. 0d. per ton on the last year of tenancy and of 6s. 0d. per ton in the last year but one.

E. M. CROWTHER.

ROTHAMSTED EXPERIMENTAL STATION.

References

1. The Report is published in "Agriculture" the Journal of the Ministry of Agriculture, July 1946, Vol. 53, pp. 163-170. Reprints are obtainable from Kenneth Glenny at 41, Whitehall, S.W.1.

2. LAWES, J. B. "Exhaustion of the soil in relation to Landlord's Covenants and the valuation of unexhausted improvements." Read before the London Farmers' Club, April 4th, 1870.

3. LAWES, J. B. "On the valuation of unexhausted manures." Second series. *J.R.A.S.E.* Vol. 36, 1875, pp. 3-40.

4. LAWES, J. B. "Freedom in the growth and sale of the crops of the farm considered in relation to the interests of the landowner and the tenant farmer." Read before the *Society of Arts*, December 12th, 1877.

5. LAWES, J. B. "Compensation for unexhausted manures." A pamphlet published by *William Ridgway*, 1883.

6. LAWES, J. B. AND GILBERT, J. H. "On the valuation of unexhausted manurial residues." *J.R.A.S.E.* 1885, Vol. 46,, 590.

7. LAWES, J. B. AND GILBERT, J. H. "The Royal Commission on Agricultural Depression and the Valuation of Unexhausted Manures." *J.R.A.S.E.* Vol. 58, 1897, 674-711.

8. LAWES, J. B. AND GILBERT, J. H. "The Valuation of the Manures obtained by the consumption of foods for the production of milk." *J.R.A.S.E.* Vol. 59, 1898, pp. 103-117.

9. VOELCKER, J. A. AND HALL, A. D. "The Value of unexhausted manures obtained by the consumption of foods by stock." *J.R.A.S.E.* Vol. 63, 1902, p. 76.

10. VOELCKER, J. A. AND HALL, A. D. "Compensation for the unexhausted manurial values of feeding stuffs and fertilizers." *J.R.A.S.E.* Vol. 74, 1913, pp. 104-119.

11. RUSSELL, E. J. AND VOELCKER, J. A. "Fifty years of Field Experiments at the Woburn Experimental Station." 1936.

12. HALL, A. D. "The duration of the action of manures." *J.R.A.S.E.* Vol. 74, 1913, pp. 119-126.

13. FINNEY, D. J. "The Little Hoos Field Experiment on the Residual Values of Certain Manures." *Empire Journal Experimental Agriculture*, 1940, Vol. 8, pp. 111-125.

14. CROWTHER, E. M. AND YATES, F. "Fertilizer Policy in Wartime." The Fertilizer Requirements of Arable Crops." *Empire Journal Experimental Agriculture*, 1940, Vol. 9, pp. 77—97.

16. CROWTHER, C. "The Chemical Composition of Farmyard Manure as a Measure of its Value." *Trans. Highland and Agric. Soc. Scotland*, Fifth Series, Vol. 24, 1912, pp. 219-236.

17. "The Residual Value of Feeding Stuffs and Fertilizers." *J. Ministry of Agriculture*, 1927, Vol. 34, pp. 401-411.

18. Department of Agriculture for Scotland. Misc. Publication, No. 7, 1940 Edition.

19. CROWTHER, E. M. "The Soils of the Woburn Plots." p. 332, Part IV of E. J. Russell and J. A. Voelcker "Fifty Years of Field Experiments at the Woburn Experimental Station." 1936.

20. See also, E. M. CROWTHER, "Unexhausted Manurial Values. Some aspects needing revision" and "The 1946 Report on Residual Values." Reports of the First and Second Ordinary Meetings of the Central Association of Agricultural Valuers, Nov. 22, 1945 and July 25, 1946.

RECENT DEVELOPMENTS IN METHODS OF DIAGNOSING MINERAL DEFICIENCIES OF CROPS

THE interest of the farming community in the mineral nutrition of crops goes back as far as 1840 when Liebig enunciated his mineral theory of crop nutrition. In doing so he advanced the view that simple analyses of crops would provide the data necessary to determine the mineral requirements of crop plants and the amounts of the mineral elements necessary to add to the soil in manures to make good shortages due to removals by crops. This was the first attempt to relate crop growth and yields with the mineral status of crops, but unfortunately the conception was an over-simplification of the problems involved, and was soon shown by Lawes in his early field experiments at Rothamsted to lead to erroneous conclusions in practice.

The Rothamsted field experiments opened up a second method of assessing the mineral requirements of crops and of determining the nature and extent of various mineral deficiencies, a method which, with its modern elaborations, remains one of the most important at the present time.

The failure of Liebig's conception led to another method of attacking the mineral nutrient problem, namely soil analysis, which is in effect an attempt to assess the power of the soil to supply the mineral nutrients required by crops. This method of soil analysis is still one of the important methods used in determining mineral deficiencies in crops, though like the method of field experiments it has undergone many refinements and elaborations in the course of long usage.

It will be seen later in this article that in recent years much attention has again been given to crop analysis as a diagnostic method, though the modern approach differs from that of Liebig in that due regard is given to established principles of plant physiology.

In attempting to diagnose deficiencies in plants it seems logical to examine both the plant, which must absorb the nutrients, and the soil, which normally supplies them, and it will be noted that modern methods use plant and soil data in complementary rôles. Years of research have shown that the nutrition of plants is a very complicated subject. Growth is not dependent merely on a supply of mineral nutrients but is determined by the complex environment of the plant in which mineral supply from the soil is only one factor. Moreover, it is not sufficient merely to add to the soil supplies of mineral nutrients known to be necessary for the crops, as many changes of, and interactions between, nutrients take place in soil, which finally determine whether or not the individual elements will be available to the crops in suitable quantities and proportions. These conditions are so complex that it is impossible to devise absolute standards for diagnosis by the use of either the plant or the soil or both, and hence the methods now used, although they can be relied upon to solve the practical problems which arise, are necessarily empirical in character.

One further point needs stressing. Experience has shown that no one method can be relied upon to provide a solution of cropping problems as they occur on the farm, and although some instances of deficiencies may be readily solved by using one method, others may require the use of several, employed in complementary and confirmatory rôles, before a complete answer to the problems can be given. Examples to illustrate this point will be given later.

The newer methods used in the diagnosis of the mineral status of plants have been developed largely since 1920, and in England their use has been greatly extended during the

war years when there was an urgent need for quick solutions of new problems which arose from the drive for increased food production and the bringing under cultivation of large areas of marginal land of unknown cropping potentialities.

The methods now used comprise the following: visual diagnosis; foliage spraying; chemical injection of leaves and stems; chemical analysis of plant organs; soil analysis; and field trials.

THE MINERAL REQUIREMENTS OF CROPS.

In farming operations the main emphasis in problems of mineral deficiencies in the past has been on deficiencies of nitrogen, potassium, phosphorus and lime, and indeed the fertiliser industry has been built up around the first three, whilst the age-long practice of liming was evolved to remedy the last. Whilst these still remain the most important deficiency problems the experience of the present century has shown that other nutrient elements are of great practical importance, and for special crops and on certain soils may be decisive factors in successful cropping. It is thus necessary to take a much wider viewpoint of mineral nutrition problems than formerly, and in this connexion it is of interest to summarise the present knowledge in regard to the mineral requirements of crops and to refer briefly to practical problems concerning the lesser known nutrients.

It is now generally recognised that certain elements are essential to the healthy growth of plants and that others, though perhaps not absolutely essential, are beneficial to the growth of particular plants, though not to all plants. Moreover, it has been shown that of the essential elements some are needed by plants in relatively large amounts whilst others are only required in comparatively small quantities.

On the above basis it is usual to classify the nutrient elements as follows:—

Essential elements:

(*a*) Major elements required in relatively large amounts: nitrogen, phosphorus, calcium, magnesium, potassium, sulphur.

(*b*) Trace or minor elements (sometimes also called micro-nutrients) required in relatively small amounts: iron, manganese, boron, copper, zinc, molybdenum.

Beneficial elements:

Sodium, chlorine, silicon, aluminium.

It is only necessary to refer here to two of the major elements, *viz.*, magnesium and sulphur.

Magnesium deficiency is of common occurrence, especially in horticultural crops, in many countries of the world, and is a serious problem in cereals, in which the deficiency is known as "acidity" disease, in Holland and in other countries of north-west Europe. In Great Britain many fruit crops are seriously affected, particularly apples, whilst failures may occur in tomatoes, potatoes, brassicae and sugar beet. Failures in cereals have, so far, been rare, but failures of both oats and barley have been seen. The deficiency is most common on acid sandy soils, but under intensive systems of horticulture it may occur on a wide variety of soil types. Sulphur has not been reported as a deficiency in crops in this country, possibly due to the fact that many of the fertilisers commonly used contain sulphates which are efficient suppliers of the element. The deficiency is known abroad in tea, cotton and some forage crops.

All the trace elements are known to give rise to deficiency problems in crops and three of them, iron, manganese and boron, are important for certain crops in Great Britain.

Iron deficiency is most common in fruit crops, particularly in pears, apples, plums, cherries, raspberries and strawberries. It is rare in vegetable and farm crops, which can often be grown without any signs of shortage under conditions highly conducive to the

deficiency (*e.g.*, on chalk soils). The deficiency seems always to occur as an "induced" deficiency, that is to say there is always sufficient iron present in the soil but it is unavailable to the plants, generally because of the presence of high proportions of carbonate of lime. In practice the deficiency has only been noted on naturally calcareous soils or on soils which have been heavily limed.

Manganese deficiency has been common during the war, possibly due in great measure to the ploughing up of soils normally under grass, such as calcareous marsh and alluvial soils, calcareous fen soils and calcareous clays such as those of the Lower Lias and Kimeridge Formations. It has also been prevalent on certain other soils such as those on the Coal Measures and certain podsolised Heath Sands, where heavily limed to correct acidity. Crops vary greatly in susceptibility, examples of highly susceptible crops being oats, wheat, barley, sugar beet, mangolds, garden beet, potatoes, sweet cherries, and raspberries.

Like iron, the deficiency is invariably induced, the soil conditions generally associated with the deficiency being high contents of lime and organic matter and often a high water table.

Boron deficiency, though widespread abroad in tree fruit crops, particularly apples, has, in this country, so far been restricted to root crops, such as sugar beet, mangolds, swedes and turnips, and brassicae crops. The distribution of boron deficient soils seems to be related to rock types, among which may be mentioned those of the Old and New Red Sandstone Formations, the Chalk and Fen Peats of East Anglia. Boron deficiency may also be induced by over-liming.

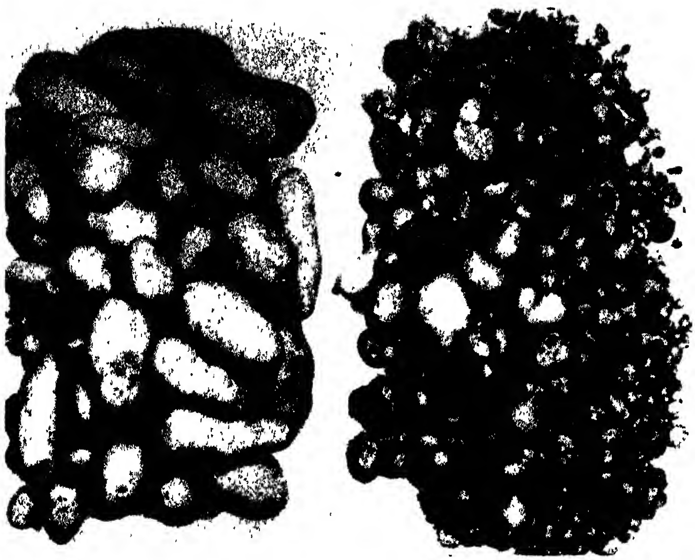
Copper and zinc deficiencies may occur in Britain as secondary deficiencies in certain crops on special soils along with iron and manganese deficiencies, but their practical importance has yet to be proved. Both are known abroad in connection with serious deficiency diseases of various crops, particularly fruit crops, but also of cereals. The problems of their availability in soils are still little known, though zinc deficiency may often be induced, as for instance by phosphatic manuring. Copper deficiency has generally occurred on poor acid peats and sands.

Molybdenum deficiency has only recently been demonstrated as a practical field problem, in forage crops in S. Australia and Tasmania. Its relationships in the soil appear to be complex, as availability has been shown to be increased by liming and by application of cobalt salts.

METHODS OF DIAGNOSING MINERAL DEFICIENCIES.

It will be clear from the previous section that it is necessary to provide diagnostic methods for all the essential nutrients, whilst in addition it may be necessary in the case of particular crops to determine the nutrient levels of the respective beneficial elements. An example of this latter is sodium for sugar beet and mangolds where low levels of the element may greatly restrict yields. The newer methods, especially those in which the actual plants are used, are particularly well suited to investigate the more uncommon and difficult cases.

Visual Diagnosis (Ref. 22). In this method use is made of the visible symptoms developed by plants which result from deficiencies of the various nutrient elements. As a large number of crops are involved, and the symptoms produced vary considerably from plant to plant, even for any given nutrient, it might appear on first consideration that the method would be too difficult and cumbersome to be of value as a diagnostic procedure. This, however, is not so, as a closer study of the problem has shown that the symptoms allow of a considerable measure of classification which enables many problems to be quickly narrowed down. Thus certain deficiencies affect chiefly the older parts of plants, *e.g.*, nitrogen, phosphorus, magnesium and potassium, and others the younger growing points



Calcium deficiency potatoes *Left* healthy tubers from plants receiving complete nutrient. *Right* unhealthy tubers from plants from which calcium omitted.

Potassium deficiency of broad beans. Internodes are short and leaf margins scorched.

Manganese deficiency of potatoes. Leaflets of terminal growth showing brown spotting along veins.

Analysis of soil acidity effects on Cauliflower—calcium deficiency, manganese toxicity complex.

a. Calcium deficiency effect shown as collapse of interveinal areas. *b.c.d.* Manganese toxicity effects (rolling of margins) in presence of high, medium and low amounts of calcium. *d.* is the common field symptom.

and meristematic tissues, *e.g.*, calcium, iron and boron. Again there are certain plants for which the symptoms of certain deficiencies are so characteristic and specific that once seen the deficiency will be always recognised for the particular crop. Examples of such are Marsh Spot in peas and beans, due to manganese deficiency, and cracked stem of celery which results from boron deficiency. In visual diagnosis leaf characters are of particular value and are largely used, but growth habits such as erectness, thickness of stem and length of internode are often important, and frequent use may also be made of blossom and fruit characters.

It is, in fact, possible to give general descriptions for each deficiency and to compile a guide for use on a wide range of crops.

Brief descriptions of two deficiencies for which the symptoms are widely different, *viz.*, nitrogen and calcium, will illustrate the characters which may be used.

Nitrogen deficiency. Growth of all parts of the plant is markedly restricted ; shoots are short, thin, upright in habit and often tinted yellow or red ; lateral shoots are few and lateral buds may die out completely or remain dormant, a condition reflected in the poor tillering of cereals : leaves are small, often set at an acute angle with the stem, usually of pale yellowish green colour in the early stages of growth and later highly coloured tints of yellow, orange and red or sometimes purple are developed ; tinting always begins on the older foliage and develops progressively towards the younger leaves ; petioles as well as laminae may be tinted . foliation and blossoming are both delayed, whilst defoliation, beginning at the oldest leaves, is premature ; blossoming in extreme instances of deficiency is greatly reduced and consequently yields of grain and fruit are small. Because of the small leaves, suppressed lateral growth and early defoliation, nitrogen deficient plants always appear thin and poorly "furnished." Fruits, such as apples, when grown under conditions of nitrogen deficiency, are outstanding for high colour, a fact which is used by growers in regulating dessert quality.

Calcium deficiency : The characteristic symptoms are shown at the tips of shoots, in young leaves, in pedicels and in root systems. The death of terminal ends of shoots is common and may lead to the stimulation of lateral growths at lower levels ; young leaves may be seriously distorted, with hooked points and rolled margins ; leaf margins may wilt and collapse or appear scorched, or they may be spotted and ragged ; the mesophyll may collapse between the veins and leaf colour is often pale green and may show a chlorotic mottling ; pedicels wilt and die, as is well shown in flax, tomato and clover : root systems are invariably poorly developed and lateral roots may remain stumpy and gelatinous in appearance ; tuber formation in potatoes may be negligible ; in contrast to nitrogen deficiency, defoliation occurs first near the growing points and develops progressively towards the older foliage. When calcium deficiency is severe the plant eventually collapses and dies and is thus a total failure.

It may be noted that in the field calcium deficiency symptoms are usually complicated by secondary effects of soil acidity in which toxic effects due to true acidity (*i.e.*, to excess of hydrogen ions) and to excess manganese are of importance.

As a basis for the visual method it is necessary to determine the various deficiency symptoms for different plants. This is done by growing the plants under controlled conditions and in sand culture, under deficiency conditions, and checking the results as far as possible by field specimens and by chemical methods. The characteristic symptoms resulting from the deficiencies are recorded by means of colour photographs which can be kept for long periods without deterioration.

In the application of the visual method in the field use is made wherever possible of indicator plants, which are simply plants highly susceptible to specific deficiencies and which show well marked and characteristic symptoms.

These indicator plants may also be combined with fertilizer treatments in field plots where difficult problems occur, and where it is desired to obtain a quick answer as to the possibility of deficiencies occurring on land of unknown cropping powers. (See further under field experiments).

Examples of suitable indicator plants for the various nutrients are as follows :

Nitrogen—leafy brassicae such as cauliflower, kale.
Phosphorus—kale, swede, potato.
Calcium—as for nitrogen.
Magnesium—cauliflower, kale, potato.
Potassium—potato, broad bean, gooseberry.
Sodium—sugar beet, mangold.
Iron—apple, pear, raspberry, strawberry.
Manganese—oats, sugar beet, mangold, potato, pea.
Boron—sugar beet, mangold, celery, swede.

For wide application the visual method requires considerable experience as its use may be complicated by many factors such as the presence of pests and diseases and weather conditions. It can only be applied in instances of fairly severe deficiency resulting in the production of symptoms, and for some deficiencies, notably magnesium, these may develop at a fairly late stage of growth. The method is very useful as a first approach to a problem and is very valuable in combination with other quick methods such as foliage spraying and chemical tissue tests.

In many instances where the visual method is to be applied it is useful to make approximate field tests of soil characters, *e.g.*, organic matter content, texture, drainage and pH, as these observations will often rule out the probability of certain deficiencies and point to the possibility of others.

Foliage Spraying. The efficacy of this method depends on the fact that plants are able to absorb mineral nutrients through their leaves, when the nutrients are sprayed on as solutions at suitable concentrations. In some instances it is even possible to apply the nutrients to the foliage as dusts but solutions are more generally suitable and decrease the danger of damage. The effects of sprays applied at suitable times in the growing season are often very quick. For instance, with iron, manganese and boron deficiencies, spectacular results may often be observed a week or 10 days after spraying. Spraying is especially suited to investigating trace element deficiencies, but it can also be useful for certain of the major elements, *e.g.*, magnesium, where responses from soil treatments are often difficult and slow. The use of foliage sprays on a field scale for supplying nutrients dates back to 1924 when Johnson used the method in the control of iron deficiency of pineapples (Ref. 7). In 1926 Gilbert (Ref. 4) and his co-workers used sprays of manganese sulphate to control a deficiency of manganese in various crops and during this same period we showed at Long Ashton (Ref. 21) that the whole of the potassium requirements of gooseberries grown as pot cultures in sand could be supplied by spraying with a 1% solution of potassium sulphate. Thus it was demonstrated that the method could be used both for major and trace elements. In recent years foliage sprays have been developed as routine practice for supplying most of the trace elements to fruit plants where deficiencies occur (iron is an exception due to the damaging effects of iron sprays). At Long Ashton we have developed a spraying method to remedy magnesium deficiency in tomatoes (a 2% solution of Epsom salts plus a spreader is used), and a similar method may be found to provide the best means of curing this deficiency in fruit plants such as the apple. Foliage sprays, in the form of overhead irrigation, are also being used successfully in vegetable culture by Mr. F. A. Secrett. It may thus be said that foliage spraying may be applied both as a diagnostic and curative treatment against mineral deficiencies.

In applying foliage sprays it is important to know the best stage at which to apply the spray and the most suitable concentration to use ; the latter because, if the sprays are too weak, they may be only partially effective, and if too strong they may produce serious damage or even cause the death of the plants. It is also generally desirable to use a "spreader" in the spray solution and for some plants whose leaves are especially difficult to wet, *e.g.*, cabbage, cauliflower, etc., the use of a spreader is absolutely essential.

For the trace elements, for treating plants out of doors, a solution of the appropriate salt at 1 oz. per 5 gall. plus spreader may be used to spray an area of 5 yds. by 5 yds.

For farm and vegetable crops a watering can fitted with a fine rose may be used and for tree crops a pressure sprayer is best. The sulphates of iron, manganese, copper and zinc are most suitable for these elements whilst borax or boric acid is suitable to supply boron. For the major elements, excepting magnesium, there is perhaps little to be gained by using sprays over the ordinary soil application of fertilisers. Magnesium can be applied as Epsom salts at 2 per cent. concentration plus spreader.

The best results for spraying are obtained when the foliage is fairly young, and indeed when the plants are at a mature stage treatments may be ineffective.

Leaf and Stem Injections. It has long been known to vine growers in France that responses to iron salts can be obtained by painting pruning cuts with solutions of these, but the first systematic study of introducing chemicals into stems was made by Bennett (Ref. 1) who published his results in 1931. Bennett was interested in the problem of evolving curative measures for iron deficiency in pears, and he worked out the details of a method for injecting solid salts of iron into trunks and stems. The method consisted essentially of boring holes into the wood of the trunks and branches, the numbers of holes per branch and the dosages per hole depending on the diameter. It was found convenient to have one hole per 1 inch. of diameter, and the holes were made around the circumference slightly "staggered" as regards level, since the bark was sometimes damaged and the staggering prevented a "ringing" effect. Suitable dosages were ascertained for the dormant and growing seasons.

This method has been extensively used for fruit trees in England for iron and manganese, and can also be used effectively, after determining suitable dosages, for any of the trace elements. As for the spraying method it is not so suitable for the major elements.

Bennett's technique has been improved by Roach, Thompson and Pizer in Kent, with a view to speeding up the work and cutting down the risk of damage to the bark. In the improved method an injection gun has been devised and the salts are introduced in tablet form. Suitable dosages of the tablets, for injections, are as shown in Table I. Similar rates are suitable for manganese but smaller doses would be required for the other trace elements, otherwise serious damage would result.

TABLE I.
Suitable Dosages of Iron Sulphate, using Tablets.*

Size of Tablet.	Diameter of Stem (Inches)	Total No. of Holes	No. of Tablets per Hole.
$\frac{1}{8}$ gramme	1	1	1
	$1\frac{1}{2}$	2	1
	2	2	2
1 ,,	3—6	3—6	1
	6—10	6—10	2
	10—20	10—20	3

* Data supplied by Dr. N. H. Pizer.

Roach (Ref. 14) at East Malling has made a special study of liquid injections and has developed suitable methods for use on crops as widely different as cereals and fruit trees. Roach makes use of the laminae and petioles of leaves, shoot tips and stems, and has developed many elegant though practical devices for making the various injections.

The solutions used are usually 0.25% strength. In making petiole injections Roach has shown that the injections are related to the phyllotaxis and that dyes may be used as preliminaries to the injections proper to show the pattern of expected responses. Liquid injections, as for spraying, are most successful when made on young, actively growing tissues. Both major and trace elements may be tested. Responses from liquid injections are usually shown within the course of a few days, the periods being generally similar to those for sprays.

It will be clear that spraying and injection methods are very similar in the effects they produce and may in fact be used as alternative methods according to circumstances and the facilities available.

Chemical Analysis of Plant Organs. In using chemical data from plants for diagnostic purposes the actual amounts of the various mineral nutrients contained in the dry matter may be compared with standards fixed from previous experience, or direct comparisons may be made in any given crop between healthy and deficient plants growing in close proximity.

Special methods of sampling plant material for analysis are necessary to make valid comparisons and in this connexion the following points require mention.

1. Laminae of leaves are usually the most satisfactory parts of the plants to use but petioles and stems are also generally suitable. These latter two are often the most suitable for tissue tests. (See below). Leaves represent the seat of active growth processes whilst other parts of the plant draw upon the various nutrients in a selective way.

2. The leaves used should be metabolically active when sampled, otherwise senescent effects may have developed.

3. Leaves for comparison should be of a similar physiological age and should be taken at the same period during the growth cycle. These two conditions are necessary since at any given time, leaves at different stages of development differ in mineral composition and the individual elements show seasonal changes.
   These two points are illustrated by the data in Tables II and III.

TABLE II.

Mineral Constituents of Young and Old Leaves from the same Plants (Cauliflower).

	% Ash in Dry Matter.	As % Ash				As % Dry Matter.				
		CaO	MgO	K_2O	P_2O_5	CaO	MgO	K_2O	P_2O_5	N.
Young Leaves	10.66	18.10	2.48	27.11	16.0	1.92	0.26	3.69	1.76	5.28
Old Leaves	13.84	33.96	1.19	22.95	8.89	4.69	0.16	3.17	1.23	3.31

TABLE III.

Seasonal Cycles of Nitrogen, Phosphorus and Calcium in the Leaves of Terminal Shoots of an Apple Tree—Values as % Dry Matter.

	Month of Sampling.					
	June	July	August	Sept.	Oct.	Nov.
Nitrogen (N)	2.76	2.32	2.37	2.22	1.84	1.59
Phosphorus (P_2O_5)	0.65	0.52	0.41	0.40	0.33	0.22
Calcium (CaO)	1.54	1.52	1.73	2.02	2.28	2.40

Different crops differ greatly in the contents of the various mineral nutrients in their leaves even when grown at the same time and on the same soil, and hence if standards are used for comparisons these refer only to the particular kinds of plants. Typical examples of rates for healthy and " deficient " plants foi five crops are given in Table IV.

TABLE IV.

Values for Mineral Nutrients in Healthy and Deficiency Plants for five Crops.

Crop	Healthy Values. (H) Deficiency Values (D).	% Dry Matter				p.p.m. Dry Matter.		
		CaO	MgO	K_2O	P_2O_5	Fe	Mn	B.
Oat (Young plants Tips)	H.	1.60	0.56	5.0	0.70	100	66	
	D.	0.58	0.15		0.20		9	
Swede	H.	5.6	0.86	4.6	0.98			
	D	1.0	0.30	1.0	0.33			
Sugar Beet	H.	3.7	0.91	5.07	0.80		46	29
	D.	0.92	0.16	0.97	0.28		17	17
Potato	H.	4.7	0.80	6.5	0.83		40	
	D.	1.0	0.34	3.7	0.20		7	
Apple	H	1.56	0.4	1.97	0.42		30	20
	D.	0.78	0.25	0.72			15	

As the result of numerous determinations, it is possible to suggest "threshold values" for some crops, below which deficiency conditions may be expected. Thus results at Long Ashton indicate that for leaves from terminal shoots of apple trees collected in late July or early August deficiencies occur below the following :

As % Dry Matter : CaO 1.0 ; MgO 0.40 ; K_2O 1.0

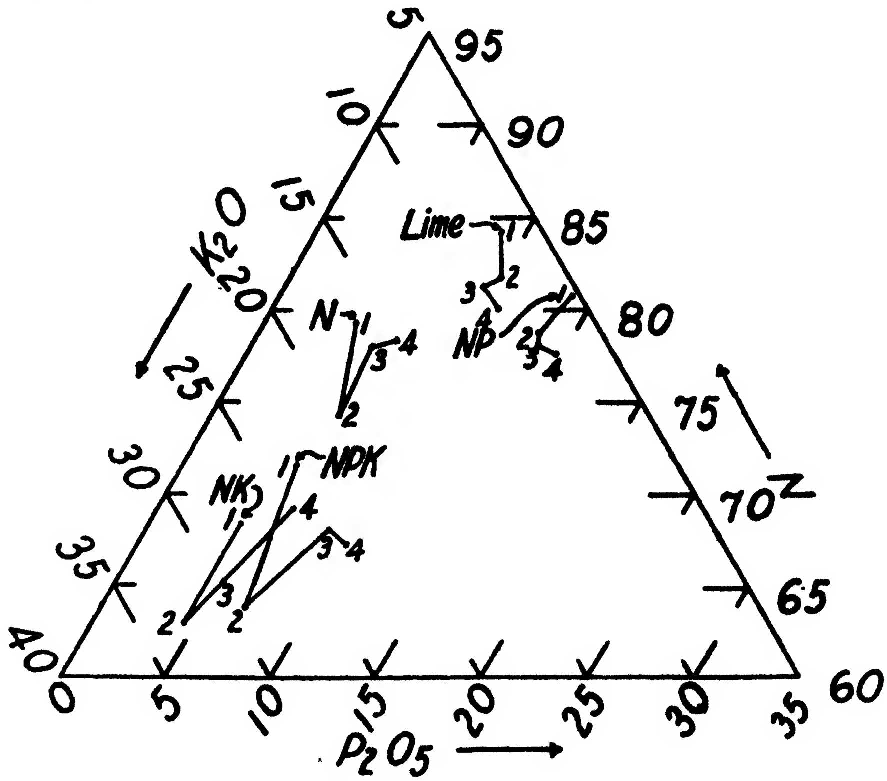
As p.p.m. : Mn 20 ; B 10.

Similar values for the three major elements have been suggested for apples in U.S.A.

Foliar Diagnosis. An elaboration of the chemical method has been introduced by Lagatu and Maume (Ref. 8) in France, which they have designated Foliar Diagnostics (or Foliar Diagnosis). The method has been widely applied to problems of mineral nutrition in U.S.A. by Thomas and Mack (Ref. 19). The essential feature of this method is that it compares the nutrient status of comparable leaves of healthy, high-yielding plants with others at various times during the growing season, the nutrient status of the former group being regarded as satisfactory. Leaves are taken from the chosen plants at selected points on three or more occasions during the growing season and determinations made of the contents

of nutrient elements in dry matter. The sum of the three percentages of nutrients is regarded as the "quantity" or "intensity" factor in the nutritional status and their ratios, on a milligram equivalent basis, as the "quality" factor. The values for the various sampling times are plotted on triangular diagrams to make the necessary comparisons of quantities and seasonal trends.

An example of the results of a typical test is illustrated in the following diagram from Thomas and Mack (Ref. 19).



Changes during the growth cycle in the N-P_2O_5-K_2O equilibrium in the third leaf. Numerals indicate the co-ordinate point of the NPK-unit at the respective dates of sampling. Treatments are [N], [NP], [NK], [NPK], [Lime].

Rapid Chemical Tests on Plant Tissues. A serious disadvantage of chemical methods as applied to mineral deficiency problems in plants is that the determinations require a considerable length of time to carry out and hence attempts have been made to develop quick proximate methods similar in principle to those evolved by Morgan for soils (Ref. 9).

In the plant tests the object is to compare the easily soluble mineral nutrients in tissues such as stems, petioles and leaf laminae, *i.e.*, the parts of the plants likely to reflect the nutrient supply at the time of the test. The technique which originated in U.S.A. (Ref. 20) is suitable for use either in the field or in the laboratory.

The method of testing consists essentially of the extraction of tissues, previously cut into small pieces, with an extracting solution (usually with Morgan's reagent—100 gm.

sodium acetate +30 m.l. glacial acetic acid per 1 litre or with normal hydrochloric acid), for a short period (say 15 minutes), pouring off the extracted solution and testing for the nutrients by suitable colour or turbidity tests. The results are assessed visually with or without the help of a comparator and may be classified merely as high, medium or low, or they may be given quantitative values. At Long Ashton methods are available for deficiency levels for nitrate, phosphate, calcium, magnesium, potassium, chloride, iron and manganese and for toxicity levels of manganese and zinc (Refs. 10, 13).

Many comparisons have been made between the results of full chemical analysis and of tissue tests and these have shown good agreement. Typical results comparing the two methods on samples from experimental apple plots at Long Ashton are given in Table V.

TABLE V.

Comparison of Visual Symptoms, Full Chemical Tests and Tissue Tests on Apple Leaves from Experimental Plots, September 7th, 1944. (Data of D. J. D. Nicholas).

Annual Manurial Treatments since 1936	Visual Symptoms of Deficiency.	Var : Edward VII.				Var : Allington Pippin			
		Full Chemical data as % Dry Matter.		Tissue Test Categories		Full Chemical data as % Dry Matter.		Tissue Test Categories.	
		MgO	K_2O	MgO	K_2O	MgO	K_2O	MgO	K_2O
No Manure	Occasional very slight Potassium deficiency	0.33	1.21	M -	M -	0.42	1.23	M	M–
N.P.K.	Slight Magnesium deficiency	0.30	2.00	M–	M+	0.23	2.51	L+	M+
		0.22	2.20	L+	M+	0.20	2.49	M-	M+
		0.34	1.95	M	M+	0.26	2.32	M	M+
N only *	Magnesium deficiency rather less than N.P.K.	0.38	1.32	M	L+	0.33	1.46	M	L+
		0.24	1.46	M—	M—	0.21	1.56	L+	M—
	Occasional trace potassium deficiency.	0.37	1.68	M	M—	0.36	1.65	M	M

*These plots also N.P.K. annually previous to 1936.

Whilst chemical tests carried out as above give clear indications of the mineral status of plants in most instances, nevertheless in some circumstances they do not supply the required information. Iron, in particular, is a striking example. As stated previously, in practice, this deficiency is probably always induced and generally there is little or no difference between the total iron of healthy and deficient plants nor is there any method known which will with certainty distinguish between the iron status in such cases. Moreover, where iron deficiency occurs as a lime-induced chlorosis the deficient leaves show abnormal amounts of calcium and potassium, the former being low and the latter high. Again iron content has been found to be abnormally high in cases of iron deficiency associated with zinc toxicity in Dolomitic soils. Such results, though perhaps exceptional, show the wisdom of confirming chemical results by other methods where possible.

Before leaving the subject of chemical methods mention should be made of the speeding up of chemical determinations which has followed from the development of the spectrograph, polarograph and the absorptiometer.

Soil- Analysis. The main problem in soil analysis in connexion with its use for the determination of mineral deficiencies in crops is that of determining the availability of the

soil nutrients to the various crops. The first notable advance in this direction was made by Dyer (Ref. 3) as long ago as 1891, when he suggested the use of a 1% solution of citric acid as an extracting agent to simulate the action of plant roots in extracting potash and phosphate from the soil.

Many other extractants have been suggested during recent years such as water, carbon dioxide solutions, ammonium acetate, acetic acid, ammonium chloride and dilute hydrochloric acid in methods similar to those of Dyer's (Refs. 12, 23). Other workers have suggested the use of micro-organisms (Refs. 16, 17) and of plants grown under standardised conditions (Ref. 18) and all have been found to give useful indications of the nutrient supplying powers of soils.

The conception of base exchange in soils has led to the development of a number of methods for determining the supplies of readily exchangeable nutrients and has also provided a new outlook on the problem of soil acidity in which hydrogen ion concentration (*i.e.*, pH), degree of base saturation and exchangeable calcium are considered in addition to the older method of " lime requirement " or lime absorbing capacity developed by Hutchinson and McLennan (Ref. 5).

Finally, methods have been evolved for speeding up analytical procedures, among which must be mentioned the quick soil testing methods of M. F. Morgan (Ref. 9) which can be used to give proximate results in the field and which are similar to the tissue tests already described.

The discovery of the importance of such elements as magnesium, manganese, boron, zinc and copper has called for methods of determining their availability in the soil and methods have been suggested for which good results are claimed (Refs. 11, 15).

All these methods when used by experienced workers can be useful in indicating the probability of the occurrence of the various deficiencies, particularly of potassium and phosphorus deficiencies, and they are especially useful in making forecasts before crops are sown. It must be recognised, however, that all are empirical and that a low value for a given nutrient does not necessarily mean that crops grown on the soil will be deficient in that nutrient. Soil analysis, in fact, in its present state of development, can only provide indications of deficiencies and is best used in a complementary rôle to plant tests.

Field Trials. As the response of the crop to a nutrient element, however applied, must always be regarded as a final test of a deficiency of the particular nutrient, field trials must always be of importance in diagnosis. In the earliest trials of Lawes and Gilbert, single plots without replication of treatments were used but the treatments were repeated annually for long periods to produce cumulative effects. This type of experimental plot, given some degree of replication, still remains of value in providing standards and in showing how nutrient deficiencies may be brought about by manurial and other practices.

Great improvements in the technique of field experiments designed to measure responses to manurial treatments and to study the interactions of nutrients have been made since 1920, but since these were discussed at length by Crowther (Ref. 2) in a recent number of this Journal it is unnecessary to describe them in detail. The main point about these newer techniques is that by the use of layouts suited to statistical analysis greater precision and certainty is obtained in the results.

A method developed especially for diagnostic purposes has been proposed by the writer (Ref. 22). In it use is made of special indicator plants, specially selected to cover the various nutrient elements, and of manurial and spraying treatments. The indicator crops are sown in parallel strips which are crossed by the nutrient treatments. The method is of special use on land of unknown cropping capacity or where more than one deficiency may be concerned. The results may be judged visually and can be checked by chemical determinations on the plants.

Although field trials measure responses to nutrient treatments, nevertheless there are conditions under which erroneous conclusions may be drawn. This is particularly true of some trace element deficiencies which may sometimes be remedied by changes in the pH of the soil. Thus applications of sulphur may remedy deficiencies of manganese and alleviate deficiencies of iron and boron by lowering the pH of the soil, and conversely the application of lime may cure a deficiency of molybdenum. Moreover, dressings of manganese or iron salts to many soils are ineffective in curing these two deficiencies which may nevertheless be remedied by spraying or injection treatments.

There are also instances in the field when fertilizer applications are too slow to be of value for diagnostic purposes. This is particularly so with fruit trees where reactions from fertilisers containing potassium and magnesium may require several seasons to become effective against these deficiencies.

CONCLUSION.

It will be evident that the recent advances in methods of diagnosing mineral deficiencies fall into two categories, *viz.*, new methods in which the emphasis is laid on the use of the crop plants and improvements in the older methods of soil analysis and field experiments.

Experience has shown that no one method will solve all problems, but each has its particular uses, and the most effective procedure is to use a combination of the different methods in a complementary way and in confirmatory rôles. In practice, different people will prefer different methods, and circumstances and facilities will often decide the final choice. It should be noted, however, that whilst certain methods require a high degree of specialist training and expensive equipment and apparatus, others can be used on the farm by technical officers and intelligent farmers with very simple equipment.

Finally it may be stated with confidence that, in the hands of suitably trained specialists, the methods now available provide the means of detecting deficiencies of any of the mineral elements at present known to be essential to the nutrition of crops.

T. WALLACE.

LONG ASHTON RESEARCH STATION,
UNIVERSITY OF BRISTOL.

References

1. BENNETT, J. P. (1931). *Univ. of California Agr. Expt. Sta. Circ.* 321.
2. CROWTHER, E. M. (1937). *J.R.A.S.E.*, **97**.
3. DYER, B. (1894). *Trans. Chem. Soc.*, **45**.
4. GILBERT, B. E., McLEAN, F. T., HARDIN, L. J. *Soil Sci.*, **22**.
5. HUTCHINSON, H. B. and McLENNAN, K. (1914). *Chem. News* **110**.
6. IMPERIAL BUREAU OF SOIL SCIENCE (1934). *Tech. Com.* 30.
7. JOHNSON, M. O. (1924). *Hawaii Agr. Expt. Sta. Bull.* 52.
8. LEGATU, H. and MAUME, L. (1924-1935). Annales de l'école nationale d'agriculture de Montpellier, N.S. 22.
9. MORGAN M. F. (1939). *Conn. Agr. Expt. Sta. Circ.* 127.
10. NICHOLAS, D. J. D. (1946). *Nature*, **157**, 696.
11. OSMOND, D. A. (1942). Long Ashton Res. Stn. Ann. Rpt.
12. PIPER, C. S. (1942). Soil and Plant Analysis, *University of Adelaide.*
13. PLANT, W., JONES, J. O. and NICHOLAS, D. J. D. (1944). *Long Ashton Res. Stn. Ann. Rpt.*
14. ROACH, W. A. (1938). Imp. Bur. of Hort. and Plant. Crops., *East Malling Tech., Com.* 10.
15. SHERMAN G. D., McHARGUE, J. S. and HODGKINS, W. S. (1942). *Soil Sci.*, **54**.
16. SMIT, JAN and MULDER, S. G. (1942). *H. Veenman and Zonen, Wageningen.*
17. SMITH, A. M. (1936). *J. Soc. Chem. Ind.* **55**, 217 *T.*
18. STEWART, R. (1932). *Imp. Bur. Soil Sc., Tech. Com.* 25.
19. THOMAS, W. and MACK, W. B. (1939). *Penn. Agr. Expt. Sta., Bull.*, 378.
20. THORNTON, S. F., CONNER, S. D. and FRASER, R. (1939). *Purdue Univ., Agr. Expt. Sta. Circ.*, 204 *(revised).*
21. WALLACE, T. (1928). *J. Pomol. and Hort. Sc.*, **VI.**
22. WALLACE, T. (1944). The Diagnosis of Mineral Deficiencies in Plants (with Supplement). *H.M.S.O., London*
23. WRIGHT, C. H. (1939). Soil Analysis, Physical and Chemical Methods (2nd Edition). *Thomas Murby & Sons, London.*

THE DRYING OF GRAIN FOR SEED PURPOSES

ALTHOUGH the artificial drying of cereal seed and of seeds in general has been brought prominently to the notice of agriculturists and horticulturists in this country in the last ten years it is by no means a new practice. It has been used for example, very generally and for a long time past, in conditioning various kinds of vegetable seeds and the rarer flower seeds, while in Ireland and the western parts of Scotland, which are characterised by a high rainfall and extreme humidity, the drying of cereal grain before storage is, by long usage, almost a normal procedure. It is also very widely practised in all parts of the country by maltsters and others who utilize home-grown grain either in the preparation of malt or of various processed foods for human consumption. As the preparation of malt of all descriptions involves the growth of the grain, drying grain for this purpose is strictly comparable with the process in relation to seeds in general, but where the ultimate destination of the grain or other seed is direct processing, drying within certain limits which will be dealt with later is done to secure good keeping quality only.

There are well-founded reasons for a wider adoption of drying in the British Isles in relation to cereals, based on what may be termed the economics of cereal production rather than on a fundamental change in the character of our climate. Undoubtedly the most significant reason for its wider adoption in recent years is the advent of the Combine Harvester which, in the period of its early appearance, was accepted as a means of lowering the cost of harvesting and threshing, the two large items of costs in cereal production. The Combine Harvester achieved this result, and it is generally conceded, moreover, that in view of the limited man power available to agriculture during the war it would have been impossible to secure the relatively vast harvests of that period without it.

At the same time it cannot be denied that the Combine Harvester brought in its train the pressing problem of storage accommodation. Quite apart from this circumstance however, the general shortage of skilled labour coupled with urgent necessities arising from the conditions of War often compelled the farmer to thresh his grain when he could, rather than when the ultimate purchaser was in a position to accept and deal with the produce. In the past, the farmer provided natural storage by stacking his grain crops, whereas he is now faced with the very immediate necessity of providing storage for grain in bulk. Many farmers have already met this need by erecting permanent, semi-permanent or temporary bins of different structure and material. Nevertheless, this provides only one, although admittedly an important feature of the total requirement, for unless grain is in good " condition " when it is placed in bins or other storage receptacles it will deteriorate more or less rapidly according to the amount of moisture it contains. Some mitigation of these effects may be realised by adequate aeration of the whole bulk of grain, but this is a tacit admission that the grain was not sufficiently dry when it was bulked to obviate the necessity of attention during storage, and involves the provision of special features in the structure of the bin or additional mechanical equipment to effect aeration. The issue is thus joined: at what moisture content can cereal and other seeds be stored in bulk safely, and if they require drying artificially, what are the best means of carrying the process out without injury to the germinating power of the seed, and without bringing about changes in the grain itself which may affect its value for commercial purposes?

With regard to the first part of the question, namely, the moisture content at which seeds can be safely stored in bulk in this country: on this very important point one is inclined to err, if at all, on the safe side, but general experience indicates that for grain, up to

but not exceeding 14 per cent. moisture is a safe maximum for bulks of a reasonable size. In seasons with average harvesting conditions this figure is somewhat below the general figure for grain as it is threshed either out of the field or soon after stacking ; on the other hand, in good harvesting weather samples with 1 or 2 per cent. less are not infrequently met with in grain threshed directly out of the field. In many other seeds, especially those that pack densely, a much lower figure than 14 per cent. is essential to safe storing.

In all cases a " safe " figure depends somewhat on the form of the bulk, that is, on the proportion of the surface of a heap exposed to the air, as in large and airy lofts and other open spaces, and on the dryness of the air. Under such conditions of storage aeration is an asset : the same but greater need for aeration exists with grain stored in a confined space, such as in many grain silos, and is then provided by transferring the grain by mechanical means from one bin to another periodically, or by forcing air through the mass of grain.

As to the means of drying grain and other seeds artificially : this is generally done by hot air and for really wet material it is at present the cheapest method, but as will be shown later there are others which may be usefully employed for small quantities of specially valuable seeds.

It may be helpful in bringing the whole question of artificial drying into proper perspective to outline briefly the underlying necessity for the operation. Before a fully ripened and viable seed will germinate three physical conditions are essential, namely, sufficient moisture, air from which oxygen may be abstracted by the young plant from the outset of its development, and an amount of heat which varies with different classes of seeds. When these three conditions are satisfied, chemical changes occur in the seed which lead to the growth of the hitherto quiescent germ, and in a few days the development of the germ becomes manifest in the appearance of a root and the first shoot in cereals, and of the root and primary leaflets in other classes of seeds. In the absence of any one of the three physical conditions there is no visible development of the germ beyond its original state. Thus, at a moisture content such as the safe storage figure mentioned above, and, of course, at lower moisture figures, there is no visible alteration in the appearance of the grain during storage, although there may be, and often are, chemical changes in the material of the seed itself. These involve the slow but continued evolution of carbonic acid gas which, if it proceeds too far and is not removed, may exercise a lethal effect on the germ. The drier the seed the less the risk of damage from this cause ; hence, the necessity for a low storage moisture figure and for the periodical aeration of the bulk unless it is initially very dry.

The need for a certain degree of heat is well illustrated in wet harvests with low temperatures when, fortunately for the farmer, and despite the provision of the other two essential conditions for growth, grain does not sprout to an extent that is unduly harmful to effective germination later. Such a limitation may, indeed, partially retrieve what would otherwise be a disastrous outcome of the present harvest. On the other hand, in harvests such as that of 1944, when the temperature after a heavy downpour in the middle of August was high, the effect on exposed crops was readily visible and permanent in its unfortunate effect.

Costs must naturally be considered in farming as in commercial affairs, and it is evident that any scheme for the storage of grain in air-free receptacles is out of the question as is also, at least for the moment, the idea of cold storage of grain. This brings us then to the artificial drying of grain as at once the cheapest and most practicable means of operating.

The aim of artificial drying should be to bring the moisture content down to a " safe " figure as cheaply as possible : the complete desiccation of seeds is unnecessary for storage, and is further undesirable in so far as it adds considerably to the cost of the operation.

Kiln-drying is, and for long has been, a widely-used method of treating grain on a commercial scale, and in experienced hands proves a safe and efficient process. But time

is an essential feature of the operation, and although relatively large quantities of grain can be dealt with in a full season of several months, the existing kilning capacity of the country is adequate to cope with the very large quantities of grain which now-a-days await treatment immediately harvesting commences. Nevertheless, since a great deal of grain is still kiln-dried, and because this method of drying has been used so successfully for many years in all parts of the country, the features of the process that have contributed to its general acceptance merit some consideration. They may, at least, be a guide in the practical use of more modern mechanical driers, and in the development which must gradually proceed from the wider use of such machines.

Although cereal grain enters so largely into the presentation of the subject it should be emphasised that with certain minor modifications, some of which will be dealt with later, almost all that is stated under this heading applies equally to other classes of seeds.

The essential structural features of a malt kiln are, first, a floor of perforated terra-cotta tiles or, less usually, of metal rods spaced to permit the ready flow of air, but to prevent the passage of super-lying grain, an air chamber immediately under the floor into which hot air from an open fire on the ground floor passes. Above the opening admitting hot air from the fire into the hot air chamber there is a metal baffle which ensures the equable distribution of the heated air over the whole under-surface of the tiled floor on which the material to be dried is distributed at as even a depth as possible. The walls of the kiln are continued upwards for some height above the kiln floor, and support an extended conically-shaped roof with a large opening at the confluence of its supporting timbers. Since there is no ingress of air except through the fire there is a continuous flow of hot air upwards through the air chamber, the kiln floor and out at the apex of the roof. The temperature of the air passing through the floor, and thence through the grain, is regulated by opening or shutting the furnace door, or by a thermostatic control which regulates the flow of cool air into the fire box. The whole building is thus designed to obtain a large volume of rapidly moving air through the material to be dried, and afterwards to conduct the air with the moisture it has acquired in its passage through the grain to the open as quickly as possible.

The loading depth of the kiln is usually 7 to 12 inches, but the exact depth varies with the initial moisture content of the grain, very wet grain being loaded much more thinly than drier grain. The installation of electric fans in or near the roof outlet of many kilns in recent years has greatly increased the rate of air flow through drying grain, thereby making it possible to load the kilns deeper and to dry somewhat more rapidly.

This brings us to the crucial point in the exposition of the subject under discussion, namely the temperature at which grain may be dried, and the rate at which drying should be effected. It is necessary at the outset to differentiate between a treatment termed "conditioning" which involves the reduction of the moisture content to a "safe" figure, and drying to a low figure with storage for an indefinite period in view. This distinction automatically separates all classes of seeds whose value depends on their capacity for future growth from those in which future growth is not a measure of commercial value.

It was stated above that the "safe" figure for storing grain is between 12 and 14 per cent., with an emphasis on the lower figure ; this is approximately the figure found in grain as it is harvested in a dry season, in other words, it is the amount of moisture present, when at the conclusion of natural ripening, the grain has undergone the process of normal desiccation. In countries with very dry climates this figure is naturally much lower, and in wetter climates it is correspondingly higher.

In "conditioning" malting barley on a malt kiln, which is in all essentials tantamount to drying seed, the temperatures adopted are from an initial 80 °F. in the grain resting immediately on the floor of the kiln, rising gradually to 120 °F. at the end of 18 to 24 hours. Once this period is passed, a further reduction of the moisture content can be undertaken

but this will require higher temperatures which, while they would have been lethal to germination in the early stages of drying, can be utilised at this later stage without injury to the germinating power of the seed. But for malting barley, and for most seeds which are unlikely to be stored for an extended period, extreme drying is unnecessary and, moreover, increases the cost of drying without securing any compensating value.

It will be noted that the salient features of drying such as that just described are low temperatures, a maximum volume of heated air to absorb and carry away expelled moisture, both operating over what, in view of modern necessities, must be regarded as an impracticable period of time. It is this limiting factor of time coupled with the expense of handling grain on to and off a kiln that has called into being the various types of mechanical driers now in use on farms, and very extensively in commerce. Claims have been made on behalf of these driers of the ability to dry at higher temperatures and with greater rapidity than was, and is still practised with the malt kiln, and some of these claims have been well substantiated. It is interesting to note, however, that in their structure and in the method of working some of the more successful plants are designed to adjust themselves to the two phases of drying already described, namely, a low and slowly rising temperature followed, where necessary, by a higher temperature which would have been lethal to germination at the commencement of the drying operation. In other words, really wet grain cannot be dried at as high temperatures as drier grain without definite risk to its germinating capacity, and it cannot be too strongly emphasised that the farmer is called upon to deal with grain at the peak of moisture content, which is also the most critical stage in the matter of drying.

It is difficult to discuss any phase of grain drying without a consciousness of the criticisms that the process as it is now widely practised by farmers has evoked in some quarters. In so far as this criticism involves combining as a method of harvesting it is generally overstated, and certainly takes too little account of farmers' practical difficulties at a time of unprecedented urgency. Indeed, in the hands of many farmers, Combining, in so far as it makes it possible to delay cutting the crop until the grain is *fully* ripe without incurring undue harvesting risks, may be the means of securing an enhancement of quality in malting barley.

On the other hand, a somewhat unexpected position has been exposed in malting barleys and in other cereals which, although ripe when cut, exhibit a high degree of dormancy and will not germinate in the normal manner even under physical conditions most favourable for growth. The causes of this condition have not yet been defined specifically, but some possibilities have been described by Dr. Bishop in the Journal of the Institute of Brewing, Vol. L. No. 4, July-August, 1944, while the study of the subject has been extended by the same investigator, and reported upon in the Journal of the Institute, Sept.-October, 1945. It is interesting to note that in his researches Bishop finds a remarkably high degree of dormancy in *Hordeum spontaneum*, the supposedly wild progenitor of cultivated varieties of barley, a result which is closely paralleled by *Avena fatua*, the common wild weed oat of our arable fields, which is so difficult to control in practice because of its dormancy or delayed germination.

In view of these experimental findings dormancy cannot be regarded as a new phenomenon, and the reason for the prominence now given to this condition of the seed appears to arise from the acceleration of the period between ripeness of the crop as distinct from its maturation and, in the case of barley, the actual malting of the grain. This leads one to regard the older methods of harvesting, first the swath, and in later times the stook, and finally, the process of " sweating " in the stack, from another angle. All these may have been no more than operations in concert with the time in which they were practised, but it is probable that what now seems to us unduly laborious methods of handling the crop

conferred a benefit on the grain which we are in danger of losing under highly mechanized systems of harvesting.

To the post-ripeness changes that were brought about under earlier systems of harvesting in the swath, and later in the stack, the term " maturation " is applied, and its importance in the assessment of malting quality was described in a striking manner by the late Dr. Beaven in his paper, " Varieties of Barley," Journal of the Institute of Brewing, July and August, 1902, as follows :

> " Other things being equal, size of grain (indicated by the weight of the individual corms) undoubtedly affects the *quantity* of ultimate extract. Quality being equal, large grain gives better extract than small. But of the two points the maturation is the more important, for large grain is very generally coarse and does not necessarily give good extracts. Malting quality depends more than anything else on maturation."

In an earlier discussion of the subject of " maturation " in the Journal of this Society, Vol. II, 1900, the same authority after describing the general course of the metabolism and katabolism of the material of the barley grain proceeds. . . . " Between the up-grade and the down-grade there is ordinarily a resting-stage, which is long or short according to the location of the seed in relation to moisture and temperature. We say there is " ordinarily " a resting-stage at this particular period, but there is no evidence, so far as we are aware, that this is an absolute necessity. Some grain which is ripe will grow under certain conditions, *i.e.*, it must be partially ripe before it is attempted to germinate it. There may be either no resting-stage, or a very short one, and that not at the usual period. But these are abnormal conditions. They do not arise in a state of nature, because the seeds do not at that stage separate from the parent plant. When grain under cultivation is cut unripe it may grow very well, provided there are, first of all, drying conditions. But the grain is not only one but two stages from being " fit " for malting purposes. Grain will grow when it will not " malt." It has first to complete an intermediate stage, during which matter " migrates " from the stem upwards to the seed, and within the seed, from the endosperm to the embryo. It will then have reached full size, and all the material for malting be present in the grain, but the material will not be in the requisite condition. Something more is still required for complete maturation."

It is generally recognised that dormancy in a great many seeds is broken by slow artificial drying, provided the grain or seed is not excessively dry at the outset. Some investigators consider that the elimination of dormancy by these means is an immediate effect, while others are of the opinion that a resting period varying from a few weeks to some months is necessary before the dried seed displays its full germinative energy. In commercial malting where drying is done slowly at a low temperature, in all essentials a close simulation to " sweating " in the stack—a period of two or three weeks is usually regarded a sufficient rest.

A very good example of the operation of the resting period is afforded by the results of some drying experiments conducted with flax seed and reported in the Journal of the Department of Agriculture and Technical Instruction for Ireland, October, 1914. The object of these experiments was to determine the maximum temperature to which flax could be subjected without entirely destroying its germination. The sample of seed used in this test had an initial germination of 86 per cent. and a moisture content of a little over 8 per cent. A portion of the sample was dried for 4 hours, and a second portion for a period of 8 hours, at temperatures starting at 144 °F. and rising to 175 °F. The germination of the seed immediately after drying and cooling, that is, after a lapse of 24 hours, and then after a period of 4 months, was as follows :

		Germination Immediately after drying	Germination After a resting period of 4 months
Sample I	Dried for 4 hours at commencing temperature of 144 °F. raising to 175 °F. ...	15 per cent.	42 per cent.
Sample 2	Dried at same temperatures as 1 for 8 hours	19 per cent.	59 per cent.

It is not clear from these tests why the sample that underwent the longer period of drying should show the higher germination value, but both samples provide evidence of the value of a resting period after what may be regarded as a severe test in respect of both the temperatures and the rate of drying.

Beyond drawing attention to Bishop's conclusion that " maturation " may be regarded as the process of recovery from dormancy, this condition of the seed in relation to Combining cannot be pursued at greater length here. Sufficient has been said, however, to indicate that the subject merits attention in evaluating Combine harvesting with its contingent drying, especially in so far as it exposes the possibility of confusing the effects of a natural phenomenon with the deleterious consequences sometimes arising from a purely artificial operation.

During the past five or six years researches on the technique of grain drying have been carried out by the Cereals Research Station of the Ministry of Food at St. Albans. The investigations undertaken by that body included the effect of different temperatures on the germinating capacity of grain of different moisture contents. The results obtained under this heading confirmed the experience gained by long practice, namely, that the higher the initial moisture content the greater the risk of damage, and consequently, the lower the temperatures that should be employed at the outset of drying (Ref. 1). Proceeding from this point it was shown that there is a steep gradient in the temperature of the grain during drying in relation to the depth of the grain : thus the grain temperature approximates to the heated air temperature when the depth of grain is shallow but falls steeply as the depth is increased. This emphasises the practical necessity of mixing the grain thoroughly during the drying operation, and recalls the well-observed practice of turning grain by hand during drying on a malt kiln.

The drying capacity of any form of drier depends not only on the temperature employed but on the rate of flow of heated air through the bulk of grain ; this, however, also requires careful regulation so as not to bring about too rapid a rise in the grain temperature which will be more damaging with wetter than drier grain.

Apart from actual damage to grain a good deal of criticism centres around unevenness in drying with the result that the whole of a bulk has not the same final moisture content. From a maltster's point of view this is objectionable for two reasons : first, if grain is underdried it cannot be safely stored unless it is re-dried, which is an undesirable procedure, in addition to adding considerably to the final cost of the grain ; secondly, since grains with different moisture contents absorb water at different rates and to different extents in the malting steep they fail to produce the evenness of growth on the malt floor which is the basic requirement of good and efficient malting. It will be noted that at the same time this condition may nullify the efforts that have been made in recent years to secure uniformity in the process of malting by the use of pure seed.

Up to this point the whole emphasis of these observations has been related to the effects of drying on the germinating capacity of seed, but it has been shown by the investigators at the Cereals Research Station that in the case of wheat they may extend to

qualitative values also where they find expression in what is termed the "extensibility" of the flour, and finally in the volume of the resulting loaf (Ref. 2). The extensibility of English wheats is found to vary from variety to variety, and in the same variety from season to season and from place to place. It is consequently difficult to state a drying temperature for any given variety without relation to the specific conditions under which it was grown, and this, even if practicable, involves very extensive tests on a strictly varietal basis. The general recommendations adopted to meet the position as disclosed by these investigations do not depart from those already outlined, namely, that the temperatures employed for wet grain should be lower than those for drier grain, and that the rate of drying should be regulated in the direction of a greater length of time for wetter material.

It will be observed from the above that the farmer-drier is faced with the problem of dealing with his grain when its moisture content is at its peak, and thus at its most critical stage for drying, and that this position may be aggravated in unfavourable seasons by a rapidly increasing accumulation of grain as harvest proceeds. The danger that then arises is a tendency to hasten drying by raising drying temperatures beyond what are safety levels, and by increasing the rate of drying. How far this position can be provided for in the future remains to be seen, but the problem is obviously one requiring adjustment between safety in operation within the limits outlined above, and speed in handling.

Reference has been made to methods of drying seed other than by heat which may be particularly desirable with small quantities of specially valuable seed. As an example of this the following figures may be of interest; they relate to two parcels of onion seed produced during the War which were required to be held over from sowing for a time. While this was the immediate object of the experiment, it was hoped that the results would at the same time furnish data for elaboration of the system of treatment at a future date.

The seed was placed in an air-tight wooden container with, in one case a considerable surface of Calcium Chloride, and in the other, Concentrated Sulphuric Acid. The moisture content of the seed used for each treatment was recorded, together with that of the seed after treatment. In the Tables which follow the germination of the seed 3 weeks and 35 weeks after treatment is added; as Controls to the treatments a portion of the seed was merely germinated, whilst two other portions were dried in hot air, for 8 hours, one at 70 °F. and the other at 80 °F.

SAMPLE I.

Treatment	Moisture on receipt *per cent.*	Moisture after drying *per cent.*	Germination (14 days test)	
			4 weeks after drying *per cent.*	39 weeks after drying *per cent.*
Control	10.28	—	97	94
Dried at 70°F., 8 hours		6.3	96	95
Dried at 80°F., 8 hours		6.0	96	93
Dried over Calcium Chloride, 7 days		5.2	97	97
Dried over Concentrated Sulphuric Acid, 7 days ...		4.0	95	95

SAMPLE II.

Treatment	Moisture on receipt *per cent.*	Moisture after drying *per cent.*	Germination (14 days test) 3 weeks after drying *per cent.*	35 weeks after drying *per cent.*
Control	10.36	—	91	—
Dried at 70°F., 8 hours	—	5.5	91	86
Dried at 80°F., 8 hours	—	4.6	88	86
Dried over Calcium Chloride, 7 days	—	4.6	92	86
Dried over Concentrated Sulphuric Acid, 7 days ...	—	2.6	89	88

It will be noted that in both samples the Sulphuric Acid is a stronger drying agent than the Calcium Chloride but that both dried the onion seed to a lower moisture figure than was obtained by hot air drying at 70° or 80°F. for eight hours. No treatment appears to have affected the germinating capacity of the seed even when the moisture content was reduced to so low a level as 2.6 per cent. This low figure, however, was obtained after 7 days' exposure to the drying agent, and it may well be that the very slowness of operation was a factor in arriving at what is approximating an extreme condition of dryness without detriment to the germinating capacity of the seed.

Apart from the preservation of the potential value of seeds by artificial drying the benefits of the process in crops such as barley extend to the resulting crop. Some indication of the nature of these benefits is evident in what has been said with regard to uneven drying in its bearing on malting. If differences in the moisture content of the constituent grains of a bulk result in uneven growth on the malt floor, evenness in the moisture content becomes synonymous with regularity in germination and subsequently development of the plant. But what happens in the malt house is an exact counterpart of the sequence of events in the field, and any advantage evident in the former is found in full measure in the growing crop : consequently, in so far as he secures evenness of germination and growth in the field the farmer is making an effective contribution towards one of the essential conditions in the production of good malting grain.

In recent years the benefits proceeding from the dusting of cereal seed with organo-mercurial compounds as a means of controlling diseases such as Leaf Stripe (*Helminthosporium*) have been so marked that the treatment has become a normal procedure in the preparation of seed corn. Provided the seed is dry when dusted and is stored under conditions which ensure the continuance of this condition, delay in sowing, often enforced by unfavourable weather, has no deleterious effect on the dusted seed. If, on the other hand, the seed is not sufficiently dry when dusted, and sowing is delayed for any reason, there may be a substantial falling off in the germinating capacity of the seed arising from the dusting. Thus, artificial drying confers a further benefit which, although unanticipated at the outset, is a very real one in actual practice.

H. HUNTER.

176, HUNTINGDON ROAD,
CAMBRIDGE.

References

1. MOUNFIELD, J. D. "Some Technical Aspects of Grain Drying." *Milling*, Nov. 25, 1944.
2. MOUNFIELD, J. D., HALTON, P. AND SIMPSON, A. G. "The Drying of Wheat. II. The Drying of English Wheat." *J. Soc. Chem., Industry*, Vol. LXIII, April, 1944.

FORESTRY ON ESTATE AND FARM

In the abstract forestry claims a great many adherents in Great Britain, nevertheless the practical aspects of woodland management for the growth of timber as a first consideration, and the implications arising from this branch of husbandry, have been far less widely understood in this country, nor have the principles of systematic forestry always been applied in woodland Britain by those who are directly concerned with the ownership and management of land. And yet, universally, the aims and objects of forestry practice are the production of raw material in the form of that indispensable commodity we know as " wood." Properly to serve their purpose woodlands need to be managed according to silvicultural system, it being as important to plant, tend and fell in due season in a forest or wood as it is on a farm to sow, cultivate and reap in proper rotation. The fundamental difference is that a " rotation " in forestry may occupy 150 years or more, a period of time which always tends to confuse the issue by reason of its long duration.

On the larger landed estates where the extent of woodland has warranted the full-time employment of trained foresters, the woods and plantations have usually received continuous treatment and have developed according to the forest policy dictated by the desires of the individual owners. In this there have been, and still are, several distracting influences all of which have tended in greater or less degree to stultify the work of the forester. On the average estate woods have had to fulfil three purposes. They have usually provided valued features in the landscape of sentimental and aesthetic interest and have been regarded as objects of beauty and amenity. A second important function has been to provide covert for the preservation and ultimate " showing " of pheasants and other game. Thirdly the woods have been the providers of timber for the estate saw mill, and posts, rails and other material for estate repairs, as well as, on occasion, material for sale to the home timber trade. In general the consequences of the distractions from the main purpose of forestry have manifested themselves in reluctance to fell at the most profitable time or to interfere with the appearance and quietude of the woods by conducting silvicultural operations as the times and seasons demand. The cry is, too often, that forestry does not pay—the answer is that a forestry denied its full purpose cannot show to due advantage where its power to create and store up wealth is handicapped by other considerations. In the balance sheet of estate forestry, as frequently practised, credit should be allowed, not only for the raw materials the woods furnish, but also for the value to the estate and its owner of all the amenities and enjoyments derived from the kind of management prescribed by the owner's wishes—a very weighty credit item in numbers of instances.

But if plans are laid with care in the light of forestry knowledge and experience, none of the amenities of country life need be sacrificed, nor need the out-turn from the woods be made to suffer. It is unprofitable, and not a little selfish to coming generations, to allow stands of timber to become over-mature and valueless where the forester's skill is quite capable of replacing old stands as they mature, by methods of selective or clear felling and regeneration, before the trees become worthless as timber. Timber trees are a crop and to reap full financial benefit the crop must be harvested and utilized or sold at the proper time. This is an axiom of all husbandry.

Although conservatism in matters of felling and silvicultural practice in the interests of amenity and covert has too often weighted the forester's accounts on the wrong side, to us in Great Britain this conservatism has proved a blessing in the great wars recently provoked by Germany. From the days of the Napoleonic campaigns an astonishing store of

timber accumulated in our woods for which the nation has owed a generous meed of thanks to British landowners. At the same time it is to be remembered that if, as a nation, we had been more assiduous with our afforestation and if our rulers of the 19th century had adopted, in time, a national Forest Policy adequate in scope to the nation's needs, many a British woodland would have been saved that has now become devastated and, for the time being, lost to the countryside. The war-time and other fellings of the past 30 years have played havoc with the exiguous total area of productive woodland in Britain, a total which has for centuries compared badly with those of the principal countries of Europe, many of which, including France and pre-war Germany, were, notwithstanding their wealth of forest, importing countries.

The chief reason why forestry has never yet been taken so seriously as a national industry with us as on the Continent lies in the fact that hitherto (except in war) we have been able to import foreign timber cheaply and readily to the extent of 94 per cent. of our entire requirements. To-day we are no longer assured that timber from overseas will continue indefinitely to be available for importation either in adequate quantity or at reasonable price. The time in which to put the estate woodlands of Great Britain into productive order and to add to the afforested areas of the country is certainly overdue. The case was ably put by the Acland Committee during the 1914-18 war and again, comprehensively, in the Report on Post-war Forest Policy by H.M. Forestry Commissioners, in 1943, and issued as a White Paper (Cmd. 6447). Those who know their subject, and something of the world timber position, cannot gainsay the findings. The Scheme of *Dedication* advanced in 1943 has now been adopted by Government and with the other measures now being adopted should provide the stimulus needed in the management of private woods.

There is, however, one plain fact that our foresters have to face. In spite of national sentiment in favour of planting native hardwood trees, we are bound to recognise that the Nation's requirements are preponderantly for softwood timbers—the wood of the pines, spruces, firs and larches—which constitute no less than 96 per cent. of all the timber consumed in Great Britain. The demand in peace or war is for the timbers of conifers, the uses of which enter into every aspect of our everyday life. These relatively light and easily worked woods cannot economically be replaced by the timbers of our oaks, ashes and beeches which, essential as they are for particular purposes, are only in request in much smaller quantity. Should events prove that we are not, in future, always so easily able to buy from abroad all the " commercial " timbers we require on reasonable terms, and there is risk of this, it follows that we must grow the balance at home. In any case it is imperative in the interests of national security to store up, within the kingdom, enough stands of the common conifers to tide over emergencies of the future when circumstances may again render it impossible to import foı all essential home requirements. There are yet further considerations and there is much to be done before our country is safe in regard to reserves of timber. At the same time there are many places in which no-one would dream of planting anything but hardwood trees and we must also be careful to cover our future requirements for these species. A Britain without oak, ash, beech and elm trees is unthinkable although, as with all kinds of timber, hardwood trees have to be cultivated properly if they are to yield mild-working, straight grained material to satisfy the wood-making trades. And we have to encourage the cultivation of a national attitude of forest-mindedness and of respect for silvicultural skill, if we are to secure the needful results of our forestry labours.

On any of the larger woodland properties the essentials for carrying out forestry programmes, apart from the provision of suitable ground, young nursery stock and tools, are the services of a trained forester, a woods' staff adequate in numbers for the work in view, and last but not least a properly conceived Working Plan. There must also be the will to see the job through because there can be no falling by the wayside if lasting benefit is to result from the

time, money and skill to be expended. Species should be chosen with regard to terrain, soils and climate. It is unprofitable to plant any kind of tree in unsuitable conditions. For instance oak and ash will not flourish on poor soils nor will the moisture loving species of conifers succeed in dry situations. Frosty places present a difficulty in the early life of most plantations except those of the hardy pines ; exposure to prevailing winds is also an important consideration. Full advantage ought always to be taken of available sources of information on special problems ; no forester should be diffident in the matter of seeking professional aid and advice because none can know everything about all the diverse influences affecting British silviculture.

In these days of rising costs it is important that no opportunity be lost for the encouragement of natural regeneration. Seedling growth of any major species and some minor kinds, such as birch, ought to be fostered carefully in order to get a crop on the ground as speedily as possible—a forest soil deteriorates rapidly if left open to wind and weather. Maintenance and tending, particularly weeding, cleaning and thinning, demand close attention to conform with Working Plan prescriptions and, in regard to utilization, local and general markets require continuous investigation, stimulation and support ; and the best form of stimulation is to afford a steady out-turn of raw material on which traders and consumers can rely.

There is one paramount duty on landowners and all others who are interested in the proper cultivation of woodland and, that is the elimination of the rabbit. Silviculture and rabbits cannot live side by side.

Forestry for the smaller landowner and farmer is beset with even more complications, difficulties and inhibitions than is the case on the larger domains, not the least of which are usually lack of practical forestry experience and knowledge of the way to make the best of local conditions and opportunities. These disabilities are often coupled with doubts whether small-scale cultivation of trees is worth while. Few small estates include sufficient woodland to provide profitable, whole-time employment for a trained forester and consequently supervision of forestry work may present a difficult hurdle to surmount. The answer seems to be in co-operative woods' management, whereby groups of woods are brought under systematic management by a forester employed jointly by the owners concerned. Alternatively recourse can be had to one of the several professional forestry consultants who are available in this country. Advice on specific problems is also given by the Forestry Commission and their officers.

Owners of woods, copses and spinnies should not take such areas for granted as places to go if a few sticks are required for local repairs : no-one, as a general rule, will cut casually into a field of growing barley or oats for fodder although few have hesitated to rob their properties of trees from time to time without thought either of replacement, the capacity of the ground for production, or of the future. Judicious planting will improve the usefulness and amenity of most landed properties and will afford shelter, improved sporting facilities and a periodic source of revenue. It is not to be forgotten that forestry is a branch of husbandry, or that there are areas on most small estates and many farms which pay little or nothing by way of annual return. Such places can, in the great majority of cases, be planted to advantage if suitable methods and species are employed. A plantation of larch, be it of one, five or still more acres in extent, is always profitable if the trees are afterwards properly tended and protected, and utilized as they grow to maturity. Likewise a coppice of ash or Spanish chestnut will provide both fencing and saleable material. Others of the conifers —Scots pine, Corsican pine, Douglas fir, or the spruces are not difficult to grow; they develop quickly and yield excellent timbers for home use or for turning into cash. The native hardwoods, oak and beech, are a long-term crop and should be planted with the understanding that they must stand for many years before arriving at full profit—with oak the period cannot fail to be a very long one. Where there is a vacant piece of ground of good

quality and not too dry, ash standards yield useful results, while poplars of the right species (black Italian, *populus robusta,* or another of the fast-growing hybrids) grow to timber size with great rapidity. Lombardy poplars are not good timber trees and the balsam poplars are not always successful. The thrifty French landowner places great faith in poplar as a revenue producer and in recent years poplar wood has been in great demand in England for match manufacture, clog-making and other uses: clean, well-grown trees have found a ready sale. Where damp, humose ground is available, and provided it is not waterlogged, that is the moisture in the soil must have a free flow and not lie stagnant, cricket-bat willow is a paying and speedily produced crop. Hitherto the growing of *salix caerulea* has been chiefly confined to the Eastern and Southern Counties of England.

Forestry on the smaller freeholds resolves itself into three headings :—

(1) The mending of badly stocked, neglected woods.

(2) The replanting (or natural regeneration) of felled woodland.

(3) The planting of land hitherto bare of trees.

There is also a fourth consideration, that is planting for shelter. But here the first consideration is not the growing of timber and, although basic principles of forestry apply in the planting and establishment of shelter woods and belts, it is clear that after-management must be directed to the main purpose in view and that rotational forestry must take a back place.

Woods in the first of the above categories can best be dealt with by planting groups or even single trees in the vacant places, bearing in mind that young trees, or transplants as they are called, must have sufficient space and direct light to enable them to prosper. If there are natural seedlings on the area they should be encouraged, thereby avoiding " artificial " re-stocking. In preparing groups for planting all rubbish that is not useful as temporary shelter is cut away ; groups should not be too large nor should too many transplants be crowded in. Oak, beech, ash, Douglas fir, Western hemlock and Sitka spruce all lend themselves to this kind of work, indeed the best ash are likely to be grown in small groups surrounded by other species. This last remark applies to sycamore also.

If there is clear-felled woodland to be dealt with the ground almost always requires preparation for planting. All useless weed-growth is cleared off, fences are repaired and drains scoured, after which the chosen species is planted in suitably spaced rows. New areas are treated in much the same way. The important points are to select the proper species to suit the soil and terrain, a matter in which the advice of an experienced forester should be sought where there is any doubt ; also to devote due attention to drainage and fencing ; and carefully to weed the newly-planted trees in course of the first two or more seasons to save them from being overgrown by ground herbage or coppice shoots. All young plantings in their early stages require protection from the competition of weeds and must be allowed free space to develop their leading shoots and side branches. In spite of care some of the trees may die in the first season or two after being planted. These may be replaced and should be if deaths occur in groups or amount in total to more than ten per cent. —in this there is no need to aim at precise mathematical perfection in the rows, as long as no sizeable blanks and wasteful spaces are left in the plantation.

Drainage is important because too much water in the soil is as harmful as too little. Moist spots, mosses and flows, in particular, ought always to be drained because trees planted in wet spots are very liable to be blown down by wind later on and to leave a " hole " in the plantation which subsequent winds are likely to extend. Adequate fencing is another essential. Farm stock are bad foresters and above all rabbits must be excluded by wire netting, the meshes of which must not be wider than 1¼ inches to be effective. Rabbit netting is an expense rarely to be avoided in this country and forms part of the tax we have to pay for harbouring these expensive forest and field pests. Needless to say all rabbits

must be destroyed within the fences before any planting is done and fences need to be patrolled periodically to prevent new runs being established.

Rabbits are not the only pests of the animal world. Hares do damage very similar to that occasioned by their smaller cousins; mice and voles can be very destructive to young transplants; squirrels, both red and grey, are mischievous, especially the former in pine plantations; and if there are deer in the neighbourhood they constitute one more source of worry. Bird life very seldom interferes seriously and even woodpeckers can be tolerated. Foresters are beginning to think it of advantage to encourage birds in the woods on account of the vast numbers of insects they destroy, a good work in which all but very few species share at one season of the year or another. There is, however, no reason to encourage the wood-pigeon. The insect horde in the forest is legion. Many kinds are injurious to trees; some are useful as predators on the harmful species and great numbers are harmless or nearly so. If insect attack develops it is best to seek advice or consult the text-books or the leaflets and bulletins published by the Forestry Commission.

Some of the fungi are also inimical to tree growth. There is the well-known larch disease, also the heart and butt-rot fungi, bark and foliage blisters, and moulds, all of which kill or interfere with tree growth. A bark-blistering fungus now prevents the successful cultivation of the Weymouth pine in Great Britain. The choice of species is often bound up with the question of pests and, again, for this reason the value of competent advice should not be disregarded.

Perhaps the most serious risk of all to young plantations is the danger of fire. Precaution cannot too urgently be stressed because plantations, conifer or hardwood, are so readily destroyed by burning and in dry weather, or after hard frost, the ground vegetation is usually in a highly inflammable state. Plantations are particularly vulnerable from the time of planting until they have grown well beyond the thicket stage and their lower, dead branches have been shed or have been " brashed " off. Fires ought never to be lighted in or near a wood and if by ill fortune a fire does start all available man-power should turn out immediately to beat it out. Live branches make serviceable fire beaters and if water is available so much the better, wet sacks being effective weapons. In plantations of any extent fire-lines on which the vegetation is kept closely cut should always be a feature of the lay-out. Fire-warning notices are useful; forest fires, large and small, are generally the result of someone's carelessness.

Planting for shelter is often an important consideration to farmers and frequently adds much to the value of exposed grazing land. Plantations and belts designed primarily for shelter are sited and laid out with reference to terrain and prevailing winds. The trees planted should be the strong rooting, wind-firm species, resistance to wind being a function of first importance in the case of shelter-belts. The species utilized should also be those calculated to grow quickly. Attention to the nature of the soil, careful planting, drainage and fencing, also subsequent weedings, cleanings, and thinnings, are equally important in this, quite separate, branch of silviculture as they are in the forest. From the point of view of forestry proper, trees planted for shelter can seldom be profitable; the principles involved are tacitly admitted in the Hill Farming Bill now before Parliament. On hillsides Scots, Corsican or Austrian pines are reliable, beech and Austrian pine being particularly suitable for shelter purposes on chalk soils; in districts of high rainfall and peaty soils Sitka spruce, which can with advantage be planted in mixture with Scots pine in many such localities, and sometimes Norway spruce, will serve the purpose. Beech is a useful standby for shelter in a variety of conditions, either pure or in mixture with conifers, and, at lower altitudes, Douglas fir, thuja or poplar quickly grow into effective screens. Planting for shelter cannot be too carefully planned and carried out. The work is usually in narrow belts, in positions of severe exposure and often on soils that are silviculturally poor. The

key to success lies largely in the choice of the right kind of tree and in seeing to it that each tree has a fair start in life.

When and how to plant are all-important considerations. The planting season in Great Britain runs from October to May, except that in localities of low rainfall it is not wise to be in too great a hurry to begin or to carry on the work long after the middle of April. Weather conditions govern the duration of the season in any given year and planting should not be attempted in very dry periods ; it is also courting trouble to put in transplants if there is frost in the ground. The actual operation of planting is usually performed with a spade and there are numerous types of spades on the market that are suitable. The Mansfield spade is a good pattern. Transplants can be planted by means of the "L" or "T" notches or pits may be dug for the purpose. Where large transplants are used pit planting although more expensive is usually the surest method. Great care is required to ensure that the rootlets are spread in position as naturally as possible. Careless planters tend to leave the root systems doubled up in the notches or holes and trees so planted very seldom flourish. After insertion in the soil the transplants need to be firmed in position with the heel. A large part of the secret of successful planting is to secure good, well-rooted, nursery stock and never at any stage to allow the roots to become dry.

Plants purchased from the nursery trade are usually delivered in bundles and when received the bundles should be untied and the plants heeled in in a sheltered spot until they are required for planting. Do not heel in the tied bundles. In a good transplant there should be balance between branch and root—a sturdy transplant with sufficient roots speedily to resume their function in the forest soil and to compensate for moisture transpired by the foliage, is one that is calculated to live in its new surroundings where a drawn-up, sparsely rooted, specimen is as likely to die. It is usually of advantage to form a small nursery on the property in which 1 year or 2 year old seedlings can be lined out until they are fit for planting. By this means it is always possible to delay lifting the plants until they are wanted for planting out in the woods so that roots have no opportunity to become dry. Little bundles of seedlings travel without much risk where larger parcels of transplants for planting direct into the woods are apt to go wrong in transit in hot, dry or frosty weather. Seedlings are also easy to raise from seed which is sown in drills or broadcast in prepared seed-beds much as garden seeds are sown, but not all private estates have the staff available to attend to seed-beds. Nursery ground must be kept clean and free from weeds. Seeds of the trees commonly used in British forestry can readily be purchased, or most of them are easy to collect from any well-formed, vigorous, mother trees there may be in the neighbourhood. Conifer seed is obtained by gathering the cones when ripe and subjecting them to moderate heat, not exceeding 100° Fahrenheit, in order to open the cone-scales for the release of the seeds. Pine and spruce cones open easily in this way but larch cones are more difficult to deal with. Douglas fir cones require to be collected before the end of September as they shed their seed naturally about that time ; most of the other cones can be gathered after the end of the year but before the late winter's sun begins to encourage them to open on the trees. Oak and beech mast are picked up from the ground beneath the mother trees in the autumn, while ash and sycamore are easily gathered as they become ripe. Ash seed does not germinate freely in the first Spring after ripening on the trees. This peculiarity which is shared by hawthorn and some others, is overcome by "stratifying," that is to say mixing the seed with sand and burying the mixture until the following season when it may be sown in the ordinary way. Where there is any considerable area to be planted, a local nursery can be made to reduce costs and the raising of young trees is an interesting business ; however, any reliable nurseryman will supply good, sound, planting stock and there is seldom difficulty in obtaining the common kinds of forest trees.

Weeding has already been referred to and while the new plantation is becoming

established this operation must be thoroughly performed whenever weeds become troublesome. The young trees are not safe from weed competition until their leading shoots are free from surrounding growths; it is also important, especially with the conifers, to allow their side branches ample room to develop and spread out in the earlier years of growth. As the plantation begins to close in and form canopy it is " cleaned " of intrusive growths, such as birch, sallow, thorn, briar and honeysuckle. Later when the struggle for light begins to become acute the trees must be thinned out periodically to allow for crown and stem development. The penalty for neglect of silvicultural thinning too often to be observed in British woodlands is a drawn-up, whippy, plantation, ill calculated to grow into useful timber.

In a period of rising prices and increasing scarcity, foresters and farmers across the Atlantic Ocean are showing a growing appreciation of the farm " wood-lot." In Canada these farmer-owned woods are stated to account for no less than 13 per cent. of the timber reserves of that vast and widely forested land. Nearer home in Scandinavia, Denmark and other countries where forestry is taken seriously, the farmer-owner of woodland is a factor of great importance in the maintenance of timber supply. The value of small areas of thriving woodland has also been thoroughly appreciated here in this country during the past seven years when timber for estate and farm repairs has been hard to come by. A strictly imposed Timber Control has throughout permitted the felling by owners up to 1,000 cubic feet of timber per month for use on the property, and owners with resources in growing timber have thus been in a much better position to maintain their estates than those who have been indifferent in past years to the principles for which forestry stands.

Tolerance of hedgerow timber is a vexed question among agriculturalists. Modern ley and arable farming would make a clean sweep of all trees growing in the hedges, and even of the hedges themselves. The arguments in favour of action in this direction are too obvious not to be well known, but there are factors that sometimes escape attention. One of these is the destruction of nesting places for birds involved in the grubbing of hedges. By comparison with Continental countries we are well off for wild life bird in Great Britain and we avoid some of the worst of the insect pests to which the mainland of Europe is subject. Any drastic discouragement of insect-eating birds may well have its undesirable repercussions in this direction; one of the things our bird friends must have is nesting places.

The growing of trees in hedgerows appertains more to arboriculture than forestry but on lowland mixed farms hedgerow trees often provide a useful reserve of timber to the farmer-owner as well as essential shelter for stock. Elm, ash and poplar are the most profitable trees to grow in this way although all of them have wide-spreading, hungry roots. It is difficult, in the mind's eye, to see England's " green and pleasant land" without its hedgerow trees which so readily replace themselves by suckers and tellers to yield timber and shelter with a minimum of attention.

The outstanding considerations in regard to our national Forest Policy of to-day are that the fellings of the past thirty years, which have included many immature stands, have left us without resources of home-grown timber worthy of the name; the urgent necessity therefore is to plant more trees. The Ministerial statement in the House of Commons of the 30th November, 1945, was to the effect that the Government were impressed with the necessity, as a safety measure, of re-building as quickly as possible our reserves of growing timber. It should be noted that the Forestry Act, 1945, which placed British forestry under the aegis of the Minister of Agriculture and Fisheries and the Secretary of State for Scotland, jointly and personally, did not bring the Forestry Commission under the control of their Departments. Subject to Ministerial direction the Commissioners remain the sole Forest Authority for Great Britain.

The programme advanced by the Forestry Commission in 1943 aims at the establishment of 5 million acres of well-managed forests and woods within 50 years and their programme for the first decade is one of replanting and afforestation to the extent of 1,100,000 acres with the recommendation that Forest Policy should be reviewed at ten year intervals and the current programme every five years or so. The Government, for reasons that are clear, could not be committed to acceptance, in full, of these long-term proposals but have made funds available for a first 5 years' quota of the Commissioners' 50 year plan, indicating also the hope that private owners of land will play a full part in the heavy task.

The Forestry Commission's Scheme for the Dedication of woods to the purpose of growing timber as a first consideration has also received Ministerial sanction. The purpose of this Scheme is to encourage the application of systematic management to private woodlands. The fundamental principles underlying Dedication are that, for national security, the woods must be put into productive order as rapidly as possible ; that landowners who are prepared to play their part, and are able to give satisfactory assurances, are deserving of financial assistance from public funds ; and that some degree of silvicultural control over private forestry is required. In fact the basis of the Scheme is that all woodland judged to be suitable and necessary, in the public interest, for the growth of timber should be utilized (*i.e.*, *Dedicated*) to that purpose or acquired by the State. The agreement to Dedicate provides for arbitration in the event of disagreement and obliges the owner to use the land for timber production as the main object, to work to a Plan, to employ skilled supervision and to keep adequate accounts. Meanwhile in return the State proposes to repay 25 per cent. of the approved net annual expenditure so long as the woods are not self-supporting or to pay an *ad hoc* Planting Grant of £10 per acre for every acre planted or replanted with forest trees, together with a Maintenance Grant of 3s. 4d. per acre per annum for 15 years for all woods Dedicated and properly planted and maintained. Loans at a low rate of interest are also offered in addition to these cash Grants. Particulars of the monetary aid available can be obtained from the Secretary to the Forestry Commissioners. Assistance is also offered by way of technical advice by duly appointed forest officers in the Commission's Service, and provision is being made for increasing facilities for forestry education and training, and research into all branches of silvicultural work, including the utilization of timber and markets.

In the adoption of a national Forest Policy in 1919, which is now expanded and reconfirmed, the Government of that day was following well behind most of the European and other governments of the world, by whom the vital importance of forestry had long previously been recognized. It is realised now, almost universally, that Forest Policy involving as it does continuous long-term planning is a matter for which only the State can properly undertake responsibility, but to bring the approved plans to fruition, and to render us, in Great Britain, secure against the hardships of a timber famine in time of emergency, and from the gradual contraction of visible sources of world timber supply, the help of everyone who may be interested in forestry is a thing earnestly to be desired.

We cannot afford to be complaisant either as a nation or as individuals. Wood is essential to our comfort and science and industry are finding more and more uses for this most useful natural product. Moreover it is beyond dispute that the world's forests are growing less and less under the ceaseless inroads of commercial exploitation and the all too frequent and wasteful forest fires.

The truth is that not enough trees are being grown to promise satisfaction of everyone's future needs ; not only ourselves but others on both sides of the Atlantic Ocean will have to plant and protect forests with a greater degree of forethought and assiduity than in the past.

Forests and woods down to the very smallest spinneys are producers of wealth. They

supply a commodity we cannot do without and cannot otherwise produce, create new employment, and do much to add to the beauty of the countryside. On all counts judicious planting is a great creative work; there is also joy in making things grow.

There is a final consideration which we, as a Nation, ought not to overlook. This lies in the wide possibilities opened up by the planting of trees in woods and forests for the permanent settlement of more families on the land. Planting creates local expansions of rural employment in the forests and by the attraction of wood working industries, which assuredly will spring up wherever new plantings are able to afford a constant supply of raw material. Past experience teaches that no potential means of regular wage-earning can safely be ignored—no-one can wish for a recurrence of the bad old pre-war days of widespread unemployment which circumstances may yet again bring about if production of primary commodities from the land is neglected. And one of these primary products is wood. The present scarcity of labour from which many industries are suffering is a temporary phase. To bring more labour to country districts on a firm basis of regular earnings can hardly fail to be of advantage from every point of view. It is a further point that there is seasonal work in the fields from time to time, haytime and harvest are the usually quoted instances and there are others, when more men are wanted. Some of the operations of silviculture can likewise be regarded as seasonal. In this forestry and agriculture can be made to dovetail together surprisingly well and where there is an established forest, men permanently engaged therein as forest workers can at times be spared to assist farmers in periods of need. *Vice versa* men temporarily redundant on the farms can often be offered work in the neighbouring forest. Actually, as elsewhere, the rural economy of this country is incomplete unless forestry and home-grown forest products play a due part. The earlier adoption of a long-term National Forest Policy with its stimulating repercussions on estate and farm forestry would have helped to stay the depopulation of the countryside which all countrymen deplore, and which is still a disturbing feature of the more remote parts of our Island.

W. L. TAYLOR.

FORESTRY COMMISSION,
25, SAVILE ROW,
LONDON.

ELECTRICITY ON THE FARM

INTRODUCTION.

ELECTRICITY supply began as a lighting service for towns. The industrial experience gained in the 1914-1918 war emphasised its value to commerce as a source of energy and power. Not, however, until the late '20's or early '30's was it appreciated that farming could provide a useful commercial load. The early legislation, beginning with the Electricity Act of 1882, was designed to direct responsibility for supply and distribution into the hands of public and local authorities. The consequence is that, wherever there is appreciable density of population, there generally the electricity supply will be found under the control of the local authority. Local authorities, with a few exceptions, have shown little interest in taking electricity to the countryside, and have been content to leave the problem to commercial undertakings who now distribute current for general purposes over an area, mostly rural or semi-rural, of 70,000 square miles with a population of 19½ millions, whereas public authorities serve 27 millions in an area of 18,500 square miles.

To secure the rights of distribution in any area a Supply Undertaking requires statutory authority, which is usually granted by Act of Parliament or Electricity Order. Any such Act or Order giving powers of Supply to a Company generally stipulates that after a given number of years the appropriate local authority within the area of supply so allocated may take over the Company's mains, etc. on paying the "then value" of the usable assets. The general effect of such legislation has been to make rural development more difficult. Powers have been conferred, however, on about twenty Companies, to supply electrical power in bulk to other authorised suppliers and to heavy industrial concerns, and these powers are held by the Companies in perpetuity. It is these and other companies who have been largely responsible for taking electricity to the rural areas.

RURAL DEVELOPMENT.

As compared with urban, rural development is expensive and requires at least 50% more capital per consumer. In the seven or eight years immediately preceding the recent war, Companies were able to attract sufficient capital to their enterprises to enable substantial progress to be made. During the last seven years the war put a severe brake on developments, but created a widespread appreciation of the benefits that electricity can confer on agriculture, as well as a great improvement in the economic position of the rural community dependent upon farming. The demand for electricity to-day is consequently very high and were it not for the general scarcity of materials, particularly wooden poles, comprehensive schemes of electricity supply, already planned, would now be proceeding very rapidly in the rural areas.

THE GRID.

In this country, electricity is generated from coal, though a few large generating stations in Scotland and Wales are operated by water power. All the main generating stations in Great Britain—there are approximately 140 of them—are linked together by what is known as the Grid. The establishment of the Grid led to great economies in plant required for generation. It also ensured that behind any area there was always a supply of electricity to meet the demand. Though the ownership and operation of generating stations is in the hands of both public authorities and commercial undertakings, the work of the Grid system is co-ordinated by the Central Electricity Board (C.E.B),who purchase all the electricity

generated and who, in turn, re-sell it to all public and private supply authorities for retail distribution.

Alternating Current (A.C.) is now almost universal. The remaining Direct Current (D.C.) systems will be converted to A.C. as rapidly as possible.

Electricity leaves the generator usually at a pressure of 11,000 volts and enters the Grid through a stepping-up station which increases the voltage in the primary circuit lines to 132,000 volts, the normal pressure at which electricity is carried throughout the Grid system. The Grid lines are carried on the now familiar steel pylons and are quite easily distinguishable from the normal rural supply lines which are carried on wooden poles.

HIGH VOLTAGE SYSTEM.

In order to supply an area with electricity a Supply Undertaking must first of all tap the Grid through a C.E.B. substation, the cost of which may be as high as £150,000. It is because of this enormous expense of reducing the pressure that a farm cannot be supplied directly from the Grid. At the substation the pressure is reduced from 132,000 to 11,000 volts, which is the normal pressure at which electricity is distributed throughout the country areas. The supply—usually referred to as High Voltage (H.V.) supply—is carried from the substation, at a pressure of 11,000 volts, to the larger centres of population and villages, and as the network of the Undertaking increases the service is thrown out to the more and more sparsely-populated districts.

In planning the routes for the H.V. lines, it is the Supply Engineer's aim to erect his mains in "rings." This method ensures that if a fault develops at any point on the line inconvenience is caused to the minimum number of consumers. Almost all H.V. distribution lines in rural areas are carried overhead, on poles, as against underground in urban areas. Overhead distribution is much less expensive and makes rural electrification economically possible, but it is much more vulnerable to damage by electrical storms, ice, snow and outside agencies. Damage is frequently caused by siting unthatched straw stacks on the prevailing windward side of a H.V. line.

LOW VOLTAGE SYSTEM.

Before electricity can be used for commercial or domestic purposes it has to be converted or "transformed" from high to low voltage (L.V.). A transformer, which looks like a small steel tank, is normally affixed to one of the poles carrying the high voltage line, but it may be on the ground.

There is a limit to the distance which low voltage electricity will flow from the transformer and do effective work. For all practical purposes it may be taken that the limit is half-a-mile. It often happens that for this reason a farm lying just outside a village which is supplied by electricity cannot itself be supplied by the village low voltage system, but requires an extension of the high voltage line and a transformer all to itself.

THREE-PHASE AND SINGLE-PHASE.

The costs of electricity distribution vary considerably in different areas, and are greatly affected if the H.V. lines have to cross over or under a railway, a main road, or telephone lines, etc. An important factor governing costs is also the type of distribution, which may be either three-phase or single-phase. A 3-phase supply is carried on three wires on the H.V. system and four wires on low voltage. Single-phase requires only two wires for H.V. or L.V.; though sometimes a 3-wire low voltage system is used. As the amount of wire, and the number of insulators, etc., is so much less, and the transformer for a single-phase system is also cheaper, it follows that a good deal of rural electrification has been done on the single-phase system. For all practical farming purposes a single-phase system will do

everything that 3-phase will do. In fact, it is really only considerations of electrical engineering, rather than of farming, which determine whether a particular system should be 3-phase or single-phase. The one practical disadvantage is that single-phase motors are more expensive than 3-phase.

COST OF FARM CONNECTIONS.

In the ordinary course of distribution, H.V. lines carrying electricity to small towns and villages naturally pass many farms which can be easily and cheaply supplied. Any farm that lies within the village L.V. supply area can also be connected without any serious expense. Under any system of distribution, however, there will always be a substantial number of farms remote from the village areas and from the route of main transmission lines. These are the farms that constitute the real problem of farm electrification. Many of them are small and can offer only a very small annual revenue. Consequently, a Supply Undertaking may not always be able to justify the high capital outlay necessary to supply them. If a farm lies half-a-mile from the main transmission line, the present-day approximate cost of a single-phase connection will be £250 for the H.V. line extension and £150 for the transformer, switchgear, etc., making a total outlay of about £400. To justify on economic grounds a capital outlay of £400 to connect only one consumer the Undertaking would require a gross annual return of round about £80. If the farmer could guarantee for a period of not less than five years that he would consume current which would give the Undertaking a revenue of £80 per year, then the farm would be connected at no capital cost to him. The Supply Undertaking much prefers that a farmer should spend his capital on electrical equipment for his farm so as to make the maximum use of the supply, with maximum advantage to himself, rather than to take only a limited supply and contribute towards the capital cost.

But supposing his requirements for current would only provide a revenue of £40 per annum, then the Undertaking would find at least £200 of the capital and the farmer or his landlord might be expected to find the rest. That is to say the cost of providing the line becomes a responsibility for both farmer and Supply Undertaking, but its maintenance and renewal are matters for the latter only. It is on general principles such as these that the amount of the capital contribution, if any, required from the farmer is based.

In the hypothetical case given above the £80 gross annual revenue would be apportioned by the Supply Undertaking as follows :—

Cost of current (payable to C.E.B.) say	£40
Depreciation at 4%	£16
Interest on Capital at $3\frac{1}{2}$%	£14
Wages, Salaries, Rentals, Rates, Taxes, General Maintenance, etc. ... ... say	£10
	£80

Capital contributions are only required where the gross revenue offered by the farm will not justify the outlay of capital involved, and where the farm cannot be included in a comprehensive and self-supporting scheme of electrification.

INCOME TAX ACT, 1945.

In addition to any capital contribution which the tenant or owner may have to pay towards the cost of the connection the cost of internal wiring and equipment has also to be met. Special relief on capital expenditure of this nature is provided for in the above Act. Provided that all conditions for relief of tax as set out in the Act are fulfilled, one-tenth of

the amount of qualifying expenditure will be allowed in each of the ten years following the year in which the expenditure was incurred.

RUNNING COSTS.

Electricity is normally sold on a " two-part tariff." One part of the tariff is a " unit " charge, usually not more than a penny in rural areas. The other part is a standing or fixed charge, which is usually based on the superficial floor area of the house and farm buildings. The idea of the fixed charge is to enable the Supply Undertaking to keep the " unit " price low and to encourage the consumer to make full use of the supply. In calculating running costs it is customary to think only in terms of the unit, which is the name given to a specified quantity of electricity and is known technically as a kilowatt hour (kWh.). A kilowatt is a thousand watts. Suppose an appliance, say an electric fire, has a loading of one kilowatt, then a unit, *i.e.*, one kilowatt hour, is the amount of electricity which would be consumed if that fire were kept alight for an hour ; that is, a pennyworth, on the assumption of 1d. per unit charge. The cost of lighting can be calculated in the same way. For example, a unit will keep ten 100-watt lamps burning for an hour, or one 100-watt lamp for ten hours.

For power uses it will suffice, for rough calculations, to take one kilowatt as equivalent to 1 h.p. To be more precise one kilowatt is equivalent to 1⅓ h.p. At a penny per unit a 1 h.p. motor will run for one hour for one penny. A 3 h.p. motor will require 3d. per hour. In this connection, however, it should be remembered that an electric motor will only consume current according to the amount of work it is required to do. For example, if a 5 h.p. motor is running and only doing the job of 3 h.p. it will consume electricity at the lower rate, *i.e.*, 3 h.p.

MAXIMUM DEMAND.

When the terms for a farm are fixed they are usually based on the assumption that at no particular time will the demand exceed a stated number of kilowatts. The type of installation is based on this assumption, plus of course, a margin for safety and reasonable extension. If, later on, it is required substantially to exceed this maximum, notice must be given to the Supply Authority who may fit a " changeover switch " which prevents two or more high consumption machines operating at the same time ; or alternatively fit a bigger transformer which will enable the higher load to be delivered without inconvenience to other consumers. For water heating, sterilising, pumping, etc., farmers can frequently have the benefit of the cheaper terms quoted for an " off peak " load by carrying out these operations only during the night or at periods during the day when the demand for current is not high.

INSTALLATION.

An Undertaking's " Supply " responsibility ends at the meter, that is, at the point at which the internal wiring begins. At that point competitive prices for wiring, equipment, etc., can be invited. It is important to invite tenders for wiring only from reputable and experienced firms who can be relied upon to use the best and most reliable materials. It is advisable also to buy apparatus made by manufacturers who specialise in electrical equipment, and through agents who understand thoroughly the purpose for which the equipment is to be used. Failure to observe these obvious precautions has led to many disappointments and sometimes to accidents.

APPLICATIONS.

The great merits of electricity are its convenience and adaptability, but to get the best results from it the farmer may have to be prepared to modify or even discard traditional methods. For example, in lighting farm buildings it is foolish to imitate the storm lantern, and hang an electric bulb from a beam where it will merely illuminate a cow's back.

Electricity gives the opportunity of doing barn work automatically with low-powered motors, and of dispensing with much supervisory labour. It also makes it possible to dispense with pulleys and shafting. An electric motor can be placed on the floor, under the floor, or on the wall. It will work upside down.

All that electricity does is to provide the energy to operate any piece of apparatus It is a form of energy or heat to be used only with equipment which has been properly designed. If the apparatus is unsatisfactory or not properly managed it is manifestly unfair to lay the blame on the electricity supply.

Most responsible Supply Undertakings have now on their staffs specialists who are competent to give the best advice available, not only on the equipment best suited for any particular job, but on how a building should be modified or designed to suit electric power. No doubt in due course there will also be on the staff of the National Agricultural Advisory Service advisers who can give advice in a general way on the subject.

The uses to which electricity can be put on the farm are so numerous and varied that it is not possible within the scope of an article of this character to do more than review some of the chief uses to which it is now being put, and to indicate some possible extensions in the future.

Lighting.

The importance of obtaining the greatest benefit from electric light cannot be exaggerated. As in the factory, so on the farm the aim should always be to light the "job." This is particularly obvious in the cowshed where it is essential that the cow's hindquarters and udder should not be in shadow but fully illuminated.

In a cowshed with a single row of standings, good lighting may be obtained by placing bulbs of not less than 60 watts in bulkhead fittings every 10 ft. 6 in. along the wall behind the cows and about 7-ft. above floor level. The fittings should be mounted at an angle on the wall to ensure that the light is directed on to the cows' hindquarters.

In sheds with a double row of standings with cows tail to tail, good lighting can be got from a centre line of 100 watt bulbs hanging from the girders or roof principals.

Where really exceptional illumination is required, 5-ft. lengths of shadowless fluorescent tube lamps will give a wonderful white light. Per unit of candle power given out the consumption of current by this type of lamp is much less than for the ordinary metallic filament type of bulb, but the initial cost of the fitting is comparatively heavy, and this device can hardly yet be recommended as a standard or general form of cowshed lighting.

In buildings such as barns, workshops, etc., where angle bulkhead fittings would not ordinarily be used all lights should be fitted with adequate reflectors which are quite inexpensive and make all the difference to the efficiency of the bulbs. Lights in outside yards, particularly those required for the assembly of milking cattle, may be controlled by a master switch in the farmhouse.

Water Supply.

The Farm Survey conducted in 1941/42 by the Ministry of Agriculture has shown that the percentage of farms connected to piped supplies of main water is not high. Electric power properly applied to a static supply of water can give to the farm all the advantages of a "mains" supply and generally at a lower cost. The type of installation will depend upon the nature of the supply available and the farm's requirements for water. The two main systems of supply are the gravity and the automatic pressure systems.

The gravity system involves the erection of a tank of sufficient storage capacity either on a platform or at some high point from where distribution by gravity to any part of the farm can easily be arranged. The method of pumping will depend on the depth of the well and the height to which the water has to be raised. Where the water level is not more

than 25-ft. below the surface a shallow well pump mounted on a platform at ground level will probably suffice. Where the well is over 25-ft. deep a deep well pump must be fitted. This can either be of the submersible type, where both motor and pump are submerged below the level of the water in the well, or a well-head gear rod-operated pump. Naturally, much of the success of the system will depend upon the efficiency of the pump installed, and expert advice should always be sought. Pumping can be automatically controlled by using a float switch, which is operated by the rise and fall of the water in the storage tank. This switches off the pump motor when the tank is nearly full and switches it on again when the level of the water falls.

The pressure system consists of an electric motor-driven pump connected to an enclosed tank from which the various pipe runs are taken. It is not possible to compress water, but by pumping water into an air-tight tank air can be compressed to a pre-determined pressure at which the electric motor operating the water pump automatically cuts out. Water can be delivered under pressure to any point in the system. When the air pressure in the tank falls to a pre-determined amount the motor automatically " cuts in." The tank need only be quite small. One hundred gallons would be ample capacity for quite a large dairy herd. This system will give all the benefits of a mains water supply and will ensure water being delivered at a pressure that will be sufficient for swilling out cowsheds and dairies, and washing farm vehicles. The disadvantage is that in the event of electricity failure there may not be sufficient storage of water to meet normal demands. Electricity supply is, however, so reliable that the risk of shortage of water due to its failure is remote.

It is possible to combine both the gravity and the pressure system without erecting an expensive storage tank and at the same time ensuring a sufficient reserve of water. Such a system is in operation at the Reading University farm, Sonning. A pump delivers water from a well to an indoor tank 8-ft. above ground level. An automatic pressure tank set is fed from this tank, and delivers a high pressure supply. If the electric current fails the high pressure set is cut out and the supply is then obtained direct from the tank at low pressure.

Where field drinking troughs are connected to a pressure system delayed action ball valves should be fitted in the troughs to prevent frequent cutting in and cutting out of the electric motor.

Any system of farm water supply will rarely require an electric motor exceeding 1-h.p.

Milking.

During the past few years, the demand for milking machines has grown enormously and will probably continue. Electricity has many advantages in providing the energy required to operate them. The motor is easily started and maintained ; it is clean, noiseless, odourless and is adaptable for fitting under almost any set of conditions. One disadvantage is the risk of current failing at milking time, but that risk is less than that of mechanical breakdown of some other form of power. The motor required will vary between $\frac{3}{4}$-h.p. and 2-h.p. according to the size of the milking plant, and will consume from 15 to 40 units per cow per year.

Mechanical Cooling.

On many farms it is pretty well impossible to cool milk to a sufficiently low temperature in summer by relying solely on the ordinary water supply. There is a high potential demand for an efficient and cheap method of mechanical cooling. The equipment at present available is costly. The possibility of evolving a cheaper method of mechanical cooling is being studied by the engineer, but there is as yet no early promise of a satisfactory solution.

Some knowledge of what refrigeration involves is necessary to appreciate the problem. The principle depends on the latent heat of vaporisation of a liquid, and on the use of a liquid which will vaporise at a comparatively low temperature. The liquid when vaporised

by the heat of the milk running over the cooler must be compressed, condensed and re-circulated. The apparatus cannot therefore be simple or cheap.

At present the chief methods of applying the above principles to mechanical cooling are by :—

(1) Direct Expansion, where the refrigerant, which absorbs the heat from the milk, expands inside the cooler, and :

(2) Brine Circulation, where pre-cooled brine is circulated through the lower half of the cooler.

For either method electricity is the most convenient form of power for operating the compressor and pumps.

Costs of Mechanical Cooling.

The difficulty in the way of an extension of mechanical cooling is the capital outlay on equipment, and not running cost, which from the point of view of electricity consumption is very low. Figures published by the Ministry of Agriculture show that the consumption for running compressor plants ranged from 1/40th to 1/20th unit per gallon of milk cooled where the first stage of cooling was by water. On this basis a 30-cow dairy, averaging 60 gallons per day, would not consume more than 3 units, with a running cost of 3d. per day.

Sterilisation of Dairy Utensils.

Electricity is both a convenient and economical method of raising steam in the dairy for the sterilisation of utensils. There must, however, be no waste of steam. No more steam should be raised than is necessary to do the actual job and that can be calculated. High working pressures are quite unnecessary. All that is needed is a boiler with sufficient evaporative capacity, a term which can be defined as "the weight of water in pounds transformed into steam in one hour." Most equipment for milk production at present on the market may be adequately sterilised by steam supply at a gauge pressure of up to 2-lb. per square inch, but only when the rate of delivery is continuous and the volume adequate. All electrical steam raising equipment has been designed accordingly. Steam can be raised electrically in several ways.

Self-Contained Chests.

Where hand milking is practised, or where a bucket type of machine is used, and there are no milk pipe lines to be sterilised, an electrically heated sterilising chest or "electric steriliser," as it is commonly named, will give entirely satisfactory results. The size of the chest required will depend upon the size of the herd, and whether or not milk is bottled on the farm. The bigger the chest the bigger will be the loading of the water heating unit. The following table is given as a guide.

Capacity Cu. Ft.	Loading kW	No. of Cows	Cost of Steaming per hour at 1d. per unit.
15	3	15 to 20	3d.
19	4	25 ,, 30	4d.
27	6	30 ,, 50	6d.
48	9	50 ,, 70	9d.

The unit comprises a cabinet or chest fitted with a front door : it has thermal lagging or cavity walls to prevent loss of heat. The steam generator is a separate unit built into the bottom of the chest. Sometimes it is built into the side, but that is rather less convenient. A short steam line connects the steam raiser to the interior of the chest.

There have been in the past disappointments from the burning out of the heating elements, but that difficulty has now been overcome. Modern chests have safety type

heating elements which automatically " cut out " when either a failure of the ball-valve or the water supply itself results in an uncovering of the elements. Inlet ball-valves may tend to stick if the water supply is hard or if the instructions of the manufacturers of the chest have not been observed. A water softener would provide the complete answer to this problem, provided the capital outlay was not too high. To avoid ball inlet valve trouble chest makers recommend adding for each hour's operation a tea-spoonful of special water softening solution through the steam inlet pipe of the chest. They also recommend that the heating tank should be flushed out at intervals of not more than one week. A self-contained chest can also be fitted with an outside steaming line, leading to a steam stool for churn sterilisation and to a line over the wash troughs for sterilising the rubber pipes and teat cup assemblies of milking machines.

Steam should be " up " within a few minutes of " switching on." The whole operation from switching on to switching off should not occupy more than one hour. A self-contained chest can, of course, be placed in the dairy. It does not require a separate building. A 27 cu. ft. chest will occupy a floor space of about 3-ft. 6 in. square and can usually be fitted conveniently into some corner of the dairy.

Steam Raisers.

Electric boilers of a larger evaporative capacity are necessary where releaser or combined recorder milking plants are in use. A 3-point auto milk recorder requires a boiler capable of delivering 1-lb. of steam per minute or 60-lb. per hour. A small boiler of say 40 lb. evaporative capacity would be capable of sterilising a 3-point " auto recorder " but the process would naturally take longer.

Steam raisers are of two main types—the immersion heater type and the electrode type.

Immersion Heater Steam Raiser.

In this type the heating element is insulated and encased in a metal sheath. The whole is inserted inside the water compartment exactly as for a self-contained sterilising chest. The loading will depend on the amount of steam required per hour of operation but will usually be somewhere between 9 kW. and 20 kW.

Electrode Steam Raiser.

In this type heat is generated directly in the water by electricity passing through the water between the electrodes which consist of short iron pipes. This affords a relatively simple construction and a compact outfit. There is nothing which can burn out and the cost of servicing and renewals is low. For technical reasons, however, they are not available in the lower ranges of steaming capacity and for dairy farm use are available in loadings of about 20 kW. The electrode system is not suitable to all types of water supply and expert advice should always be sought from the Supply Undertaking before deciding to buy.

Whether steam is raised by immersion heater, or by electrode, the boiler is a separate unit and does not form a part of the cabinet as is the case with the self-contained chest. Steam raisers, like the self-contained chest, can be housed in the dairy. Economy of space, can, therefore, be effected either where a new dairy is being planned or where alterations are contemplated to existing buildings.

Water Heating.

The normal method of heating water in a dairy with the ordinary fuel fired type of boiler is to inject steam from the boiler direct into a trough of cold water. The same method can be imitated, and unfortunately, is practised, where electric steam raising equipment is available. A certain amount of hot water can also of course be drawn from the boiler. Either method is clumsy and does not make full use of the automatic properties which a supply of electricity affords.

The neatest and most satisfactory way of providing a constant hot water supply is by installing an electric storage water heater. By this method water is heated in a thermostatically controlled and lagged heater, a type of equipment frequently seen in domestic use. Provided the storage heater is of ample capacity hot water will always be on tap. The thermostat can be set to any required temperature.

For a wash hand basin 1½ gallon capacity is sufficient but for general use in the dairy the capacity of the heater will be governed by the size of the herd. A 100-gallon heater might be required for a really large herd. The local electricity supply engineer will be able to advise on the capacity required to meet the needs of any individual case. Very often these storage water heaters are given a " domestic " finish, with beautiful white enamel casings. These are not necessary in the ordinary dairy. A practical electrical engineer ought to be able to arrange for the thermal lagging of some inexpensive tank suited to local conditions and so keep down capital outlay. The running costs of a storage water heater are low. The load is one which is popular with electricity supply undertakings. It gives them an opportunity of offering a special tariff. A normal 1d. rate might be expected to fall to ¾d. per unit. As a rough guide to electricity consumption it can be taken that one unit will provide 3 gallons of hot water at 170°F.

The Barn.

According to all reliable forecasts, farming in Britain for some years will have to maintain a " self-sufficiency " policy which will demand a considerable acreage of arable crops with consequent grinding, preparation and mixing of food in the barn.

Where electricity is not available it is usual to find in farm buildings a stationary engine of some sort turning a line of shafting with belt and pulley take offs to a crushing or grinding unit, a cake breaker, a chaff cutter, a root pulper, etc. Where a fixed engine is not available then the shafting may be driven by a farm tractor, brought, often at great inconvenience, to the barn specially for the purpose. Labour has always to be in attendance to supervise engine and machine.

Where electricity is available each machine can be driven direct by its own motor, *i.e.*, the unit drive principle. More and more farmers are turning to that method. Its advantages are obvious, but where capital outlay has to be carefully watched there is no reason why an electric motor should not be coupled to more than one machine. It would be waste of current, however, to have a motor turning a long line of shafting to operate only one machine.

The Electricity Supply Engineer, in designing a power layout for a farm, is always anxious to secure an even spread of his load over the day. For example, he would much prefer to instal a machine with a 1 h.p. motor which would have to run 20 hours a day than a 20 h.p. motor which would only have to run one hour a day. That is a simple economic consideration which applies to most forms of business.

The Engineer has, therefore, gone to considerable pains to design a grinding unit which will satisfy his conditions of supply and the farmers' requirements. A small hammer mill is one result of his work. The mill is designed to grind cereals, peas, beans, etc., either separately, or mixed, to any desired grist. It is very efficient for the production of meal for stock as normally required on the farm, and has a capacity of from 10 to 16 bushels per hour. It is not designed for grinding roughage and straw, the desirability of which in any case may be questioned on nutritional grounds.

The unit consists of a mill with suction feed, bedplate and fan. The ground meal is blown through overhead pipes to cyclone or storage bins placed at any convenient point within 30 feet of the grinder. The standard unit normally includes a built-in 3 h.p. electric motor with a V-Belt drive to the mill. With continuous corn supply from an overhead bin, an electric cut-off switch can be fitted into the hopper to shut down the plant auto-

matically as soon as the supply of corn is exhausted. Supervisory labour is, therefore, unnecessary after the plant is once started, and it can be left running, even all night, unattended. The motor and unit combined looks a toy, but if it is a pigmy amongst machines it does the work of a giant.

Ideally corn should be hoisted to an overhead granary and there fed into a bin or hopper which will discharge by gravity into the mill on the floor below. The mill and hopper can, however, be fitted quite conveniently into a single-storied building.

The collection of meal is by cyclone which separates the meal from the air, delivering the meal into a bin, or into a sack or on to the barn floor. Alternatively, the meal can be blown direct into an enclosed bin provided there is adequate escape for the air to a cloth balloon or other filtering device. Two-way valves can be fitted in the pipe runs to allow of delivery into any one of a number of bins or to a cyclone as desired. The meal storage bin can be arranged to feed by gravity into a mechanical food mixer, and the whole process from grinding to mixing can be operated automatically.

Some farmers feel that the output is so small—the maximum is about 4 cwts. per hour—that they insist on having a larger unit. This may sometimes be justified, but there are remarkably few conditions that the 3 h.p. unit will not satisfy when it is remembered that :—(*a*) the whole operation can be automatically controlled, (*b*) the motor and mill can run for many hours without supervision, (*c*) meal is better for being freshly ground and not stored for an appreciable time.

Threshing.

Where corn stacks are built or are scattered all over a farm electricity has not much scope as power for threshing. Where, however, corn sheaves are stored in a Dutch barn or are stacked in a yard it is quite simple to arrange a number of suitable outside plugs to which a motor can be connected. Generally speaking, transportable motors are not to be recommended for farm use, but an exception has to be made for threshing. The same motor could also very conveniently be used to drive a circular saw.

Where threshing machines are "built in," as they are in Scotland, electricity is an ideal form of power. If applied to all the auxiliary operations such as self-feeder straw-carrier, elevator or corn conveyor, etc., the labour required for threshing can be limited to one or two men.

Grain Drying.

The stimulus given by war conditions to grain drying has resulted in an increased demand for electricity to supply the power to drive elevators, fans, cleaning machinery, etc., associated with grain drying plants. Where current is available the whole installation can be driven as one unit by a high horse-powered electric motor. Most modern installations however, provide separate electric motors for fans, conveyors and cleaners. It is uneconomical to drive the whole plant if only one operation requires to be done, *e.g.*, predrying storage or final cleaning.

In corn drying accurate temperature control is essential. As electricity can provide complete thermostatic control, and other advantages, plants are now being installed using electricity for heating as well as for power. This can be done either by converting a solid fuelled type drier or by using a machine specially designed, and suitable only, for electricity. The latter promises to be the more economical in running costs. There are a number of successful conversions of coke-fired grain driers to electric heating. In some the banks of electric heaters are controlled by thermostat and in others by a combination of hand control and thermostat. This makes possible a wide range of temperatures which can be maintained within very narrow limits.

Although the cost of drying a ton of corn is higher than with solid fuel, accurate

temperature control, and the ability to run at a temperature nearer the critical temperature, cleanliness, labour and time saving, are factors which can be set off against the increased cost of fuel.

The number of units consumed per ton of grain vary. The average number of units consumed per 1% of moisture removed per ton of grain in one drier was 18.3. Assuming electricity to be 1d. per unit and the average extraction 6 per cent., the cost of electricity would be 10/- per ton of grain dried.

In one grain drier designed specially for electricity as the heating agent, the whole process is carried out over a series of four self-emptying trays, placed horizontally, end on end, and each at a slightly lower level. During operation the trays are in continuous oscillation. The grain is kept moving by a " bump " action on the trays and passes from one tray to the other. The floors of the trays are slatted and through them air is blown. Each tray has its own separate fan and air feed and, in the case of the first three trays, its own heating system. Hot air is forced through the grain in the first three units at accurate temperatures, thermostatically controlled. Cold air is blown through the fourth, and last, tray. Loading for heating amounts to 257 kilowatts (kW.). In addition, there are motors to operate the fans, elevators, etc. which require a further 14-kW, making a total of 271-kW. In twelve months' operation, 2,163 tons of cereals, pulses, clover and rye grass seed, linseed, etc. were dried, the average moisture extraction being from 9 to 10 per cent. Consumption of electricity amounted to 287,423 units or approximately 14 units (kWh.) for every 1 per cent. of moisture removed per ton. Assuming the cost of electricity to be 1d. per unit and the average moisture extraction to be 6 per cent., fuel costs for drying alone would amount to 7/- per ton.

Drying grain in ventilated bins offers an alternative to either type of drier ; *i.e.*, converted or specially designed. At first sight the method appears attractive where the farmer cannot afford the capital outlay for a drier, but wants to " combine " his grain and keep part of it over winter for feeding to stock. The present method is to store grain in bins with slatted floors and to blow, by electrically driven fan, a large volume of slightly heated air, or air at atmospheric temperature, through the grain. Blowing may have to be continuous or for many hours at a time. The fans can be quite small, however, and the horsepower of the electric motors quite low. The process can be made entirely automatic, requiring little supervision. The thermal efficiency of the process is higher than that of a drier because the air will leave the bin nearly saturated. This improvement is offset to some extent by having to blow and heat the larger volume of air required to remove moisture at relatively low temperatures.

The Workshop.

In the workshop electricity is indeed the handmaiden of the mechanised farmer or the farm mechanic. Its first advantage is, as in the barn, that it makes it possible to dispense with a line of shafting and pulley and belt " take-offs." Each machine, *e.g.*, lathe, can have its own motor with direct or V-belt drive and can be placed anywhere on the floor that is most convenient from either a space or daylight point of view. Other advantages such as immediate readiness at the touch of a switch are obvious. The advice of the Electricity Supply Engineer should be sought before finally deciding the layout of a new workshop. His ideas on economy in installation, use of power, etc. are certain to be of value.

Most machines will require only fractional horse-powered motors with consequent low running costs. For instance, an electrical lathe with a motor of $\frac{1}{3}$-h.p. will be capable of dealing with articles of diameter up to 4 inches and up to 30 inches in length. Smaller units will be required for a high speed carborundum wheel, a saw for accurate light work, portable boring machine, etc. A small compressor will make it easy to keep all pneumatic tyres at the correct pressure and an electrically-heated vulcaniser makes the patching of

inner tubes a satisfactory job. An electric heater will save tractor and lorry engines against damage by frost and ensure easy starting on cold mornings. A battery charger which can be plugged in at nights will add to the life of self-starter batteries and make early morning starting more certain.

Unless a farm supply has its own transformer the Supply Engineer is not too keen on electric welders. Though extremely useful in an experienced and skilled mechanic's hands they require a heavy loading—that is they put a heavy demand on the supply system—the load is momentary and intermittent and in the Engineer's language: "may bump his mains." The sudden load put on the supply lines by the switching on of an electric welder may cause a momentary diminution of supply to other appliances on the same distribution system and lead to complaints from other consumers. This difficulty does not arise of course where the farm has its own transformer.

HORTICULTURE.

Electricity has an equally wide range of application in horticulture. It is a cheap and convenient form of power for the fruit-grower who has his own apple grader, cold store, central pumping station for spraying, etc., or for the market grower who has machines for vegetable washing and packing, bulb grading, plant for overhead irrigation, etc. It will be sufficient perhaps to discuss two uses which are increasingly attracting the attention of the grower, namely—soil warming and heating glasshouses.

Soil Warming.

Heating by electricity provides the market grower with an alternative to horse manure for his hot beds and Dutch lights. The method has been in commercial use for long enough, and on a sufficiently large scale, to establish its economic soundness. It has shown that there is no need to maintain soil in a frame at any given temperature, but that if carefully controlled "doses" of heat are applied daily and proportionate to the area of the frame satisfactory results can be obtained. The amount of energy required is 40 watt-hours per square foot of soil surface per day for the southern and warmer areas, and 45-watt-hours for the northern and colder districts. In practice that can be applied by a loading of 5 watts per square foot for 8 hours a day or 2 watts per square foot for 24 hours a day. If the latter method is chosen, then no daily attention to switching on or switching off is required. By the former method the heat can be applied during the night when possibly a more favourable tariff could be obtained. The thermal storage properties of the soil render either method equally capable of maintaining adequate temperatures during the actual heating period.

Bare (*i.e.*, uninsulated) galvanised steel wires, supplied through a transformer which steps down the voltage to a very low value, are laid at from 6 to 7 inches below the ultimate soil surface. Skilled guidance is required in the method of laying and protecting the wires which, once laid, should not be moved again. The soil above the wires is then prepared for planting in the ordinary way.

The heat is switched on a day or two before planting out. The cost of running can be calculated as follows:—Assuming a surface area of soil of 1,200 sq. ft., the cost of electricity to be ¾d. per unit (special rate for a night load), and 40 watt-hours are required per sq, ft. per day, then consumption costs will be:—

$$\frac{1{,}200 \times 40}{1{,}000} \times \frac{3}{4} = 3/\text{- per day.}$$

It is then a simple calculation to estimate the number of lettuce which can be grown on that area and the number of days on which heat will have to be applied to arrive at the cost of electricity required per lettuce grown. In practice consumption has worked out at 1.38d.

to 1.54d. per lettuce, which may not be considered extravagant if out of season produce continues at a satisfactory price.

Glasshouses.

Economically electricity is not a suitable form of heat energy to replace the solid fuel boiler of the ordinary glasshouse hot water heating system. Electricity will of course provide the power to operate a mechanical stoker. Then, too, a method of thermostatically controlled electrical heating can be fitted to hand-stoked boilers to supplement the heat if the temperature of a glass house, during the night, should fall below a pre-determined temperature. Some growers feel however that this method may encourage inefficient stoking.

Whilst electricity may be too expensive for space heating, that is heating the air in the glasshouse, it certainly has a future for warming the soil before tomato planting. All growers do what they can to raise the temperature of the soil to 57 °F. or 60 °F. to a depth of 8 inches before planting, and use enormous quantities of solid fuel in so doing. Steel wires of the bare uninsulated galvanised type already mentioned, laid at a depth of 12 inches to 15 inches below the soil surface, and fed so as to give a surface loading of from 5 to 6 watt-hours per square foot, will raise the temperature at 8 inches to the required value in about 30 hours continuous running.

Allowing for a standard glasshouse bay of 100 ft. by 14 ft. the consumption of electricity will be of the order of 240 units, or £1 at 1d. per unit, which is considerably less than the cost of coal for three weeks running, and there is no gamble as to what the temperature of the soil will be at the end of the heating period.

POULTRY HUSBANDRY.

Electricity has a wide field of application in poultry husbandry. Its value for incubation, for lighting of intensive laying houses, for rearing appliances, for heating water, for pumping water, for grinding and mixing food, for plucking, for cold storage, its freedom from fumes, risk of fire, etc., have been freely demonstrated.

The poultry farmers' main anxiety regarding electricity supply is its reliability. It has already been shown that in the erection of high voltage lines in "rings" the engineer is pretty well able to guarantee his supply against any prolonged failure except in the most unusual circumstances. Where they arise there are few appliances which will involve the poultry farmer in much loss even if the supply is cut off for an hour or two. In incubation, failure of current is not so important from a loss of heat point of view as from interference with ventilation. In the event of temporary current failure, the Supply Engineer will always be able to advise whether emergency measures are necessary or not, either for air circulation in an incubator or alternative methods of heating for brooders.

Most disappointments in poultry husbandry arise from ill-designed equipment or from indifferent management of suitable appliances. There may be a case for the establishment of an official testing centre for electrically-operated poultry appliances, but there can be no excuse for the disregard of manufacturers' instructions for the handling of any particular appliance.

FUTURE DEVELOPMENTS.

Field Cultivation.

A satisfactory and economic method of applying electricity to large scale and general field cultivation is not within sight. The two methods of doing field work electrically are :—

(1) By a stationary, but movable, cable winding set.

(2) By a tractor fed by a flexible cable connected to a power point.

The first method has its enthusiastic supporters. It is really an electrical replica of steam cultivation with the added disadvantage that the cable units, unlike steam, are not self-

propelled and have to be moved from field to field by some other form of power. Ploughing has been done electrically by this method over a period of many years, but it does not appear able, as yet, to compete with the farm tractor for initial cost and adaptability.

The second method is the closest imitation of the ordinary farm tractor. The difficulty lies in the trailing flexible cable required for "plugging in" to the power socket. The amount of cable which the unit can carry and the handling of the cable put restrictions on the distance it can travel and its general manoeuvrability.

Small-scale application for lawn cutting and rotary hoe cultivation for market gardens is already established and provides no difficulty once the knack of handling the trailing cable has been mastered.

Hay Drying.

The application of electricity to drying or curing hay is standard practice in America and Sweden. In these countries the farm buildings are designed for the purpose. In Britain farm buildings follow quite a different pattern and different methods of application have therefore had to be tried. Hay drying must not be confused with grass drying which is quite a different process. Experiments have recently been conducted at a number of centres in Great Britain by the Electrical Research Association (E.R.A.) but the results have not yet been published.

Briefly, the method employed is to cut the hay and allow it to wilt in the sun for a few hours when the moisture content should fall by 15 or 16 per cent. The hay is then carted and heaped to a depth of several feet on ducts laid at ground level in a section of enclosed Dutch barn. Air at atmospheric temperature is then blown through the ducts until the hay is dry enough to be baled or stored. The process cannot be continuous ; the hay must be dried in batches. The quantity that can be dried in one batch must depend on the capacity of the plant installed. During wet weather, when the humidity of the atmosphere may be so high as to render drying by cold air either impossible or very slow, an electric heater can be used in the air flow system, though of course costs for current consumption will go up. There is enough evidence to show that, irrespective of weather conditions, first-class hay can be made by this method. Though the best technique and the ultimate economics of the process still have to be investigated, the indications are that electricity costs will be less than £2 per ton. It would help the Engineer if the farmer could tell him what additional value could be put on hay per ton if it could be guaranteed that whatever the weather conditions a proportion of his hay crop would always be secured in first-class condition.

Irrigation of Field Crops.

Overhead systems of irrigation for the finer market garden crops and some of the soft fruits have sufficiently proved themselves to make their extension certain. Consideration is now being given to applying the process to the dry and light land areas of Eastern England for root crops, such as sugar beet, and for green crops, particularly lucerne, grown for drying and grinding into meal. For the latter process capital outlay in plant is so heavy that growers argue that crop failure, due simply to conditions of drought, cannot be risked. The system, where both water, in sufficient quantity, and electricity, are available may be worth careful consideration.

Quick Freeze.

The term "Quick Freeze" is applied to a process, now extensively practised in America, for example, of subjecting food to a very low temperature and freezing it through completely in the space of a few minutes. Slow freezing of foodstuffs has been practised for very many years. The product obtained by the old process was not always of first quality. Produce put into a cold store at 10 °F. may take a week to freeze through completely. The

ice crystal formed is so large that on thawing it ruptures the cell structure of the produce and essential juices are lost by drip. The resulting produce therefore tends to be dry and lacking in flavour.

By the " quick freeze " method the ice crystal is smaller and there is little or no fracture to the cell structure on thawing out. The method does ensure produce of initially high quality coming out of cold store in really first-class condition after a period of storage of indefinite length. The process does not offer an alternative market for surplus produce. It offers an entirely new market, with a retail sales system behind it, for vegetables, certain soft fruits and poultry of the very highest quality. But for the war the process would, no doubt, have already been established in Great Britain. It is already being used in the fish industry. It is safe to assume that in time it will find a place in horticulture and poultry and that when it comes it will affect substantially practice in both these industries.

Feeding Cattle.

One enterprising firm has made plans to build and equip yards for fattening cattle so that all the processes of food preparation, feeding, dung filling, etc. may be "electrified" as far as possible. The general design provides for Dutch barns on either side of a " built-in " threshing machine from which chaff will be blown direct to the covered yards and the straw carried by mechanical conveyor to either the " courts " or straw barn. The corn will be delivered into the food store, elevated and fed automatically into a hammer mill, and carried to a mechanical mixer which will be connected to the cake breaker, etc. The farm is in an area where turnips are extensively grown and fed in large quantities to fattening cattle. Storage is provided at either end of the food store for the roots which will be conveyed mechanically to the pulper and thence to the conveyor. All food will be carried in self-opening conveyors, on an elevated mono rail, to receiving hoppers slung above the feeding manger, and which by operating a time switch will in turn be swung open automatically. The cattle can all be fed at precisely the same time. The experiment is bold and expensive and no doubt will require much modification before it finally becomes a success.

CONCLUSION.

Completion of electrification of farms in Great Britain calls for huge quantities of materials for the apparatus and lines of distribution, internal wiring and equipment. The job is an enormous one and will involve Electricity Supply Undertakings and owners and occupiers of land in substantial capital expenditure. It will also take time. Supply Companies, assuming materials and skilled labour to be in reasonable supply, have given the National Farmers' Union an undertaking to expand further their already extensive networks and mains so as to make electricity available to not less than 95% of all farms within a period of five years. The task can be made simpler and easier by a closer and better understanding between farmers and Supply Engineers, by the farmer and land-owner giving every possible facility with wayleaves so that the Engineer can follow the quickest and cheapest route, always compatible with farming practice, by encouraging all farmers in an area to join in a scheme for electrifying a neighbourhood, and, once current is available, by using it freely but economically for farming as well as for domestic purposes.

J. C. LESLIE.

30, Gillingham Street,
London, S.W.1.

THE COMING OF THE MANGOLD

A NEGLECTED EPISODE OF THE AGRICULTURAL REVOLUTION.

The introduction of the rootshift to the farmers' rotation marks a turning-point in economic history comparable to the coming of steam-power to industry. Not only did it substitute a cleaning crop for the traditional and wasteful bare fallow but it ended the annual slaughter of cattle which had for so long set rigid boundaries to farming progress. After that time, therefore, there was no more need for the farmer, " when," in Dante's words, " fails his wintry store " of hay and he looked out on the still snow-bound plain to

" Pace to and fro, wailing his lot,
Like a discomforted and helpless man."

For it was economic need and not poetic fancy which lay behind the craving for spring in the old ballads and when the warm weather and the fresh grass tarried cattle died and later man went hungry. Hence the almost mystic significance of the turnip in the eyes of men like Young who regarded it as the Ark of the Covenant of the New Farming.

For it is on the turnip that the historical limelight falls and the name of Townshend figures prominently in all accounts of the Agricultural Revolution. Nevertheless, the story of the mangold, though far less well-known, is as interesting and perhaps as important, for then as now the turnip suffered from one dangerous defect, its attraction for the ever-present " fly " or " flea-beetle " which, it is clear from the *Correspondence of the Bath and West Society,* scourged the crops of the time. Young, for instance, who himself lost an entire crop despite two and in parts three sowings, estimated that the fly on an average destroyed one turnip-harvest every five or six years and the numerous letters on the subject illustrate at once the anxiety and the methods of the time.

Even today there is no answer to this pest and the men of the 18th century worked out their own empirical and presumably less successful remedies, though hampered in at least one case by the belief that the fly was " engendred or at least enticed by the muck." Amongst many other things dragging with elderbush or, more drastically, scattering the fields with putrid lobsters " to leave effluvia," sowing after rain under a full moon so that the plants would grow away from the pest, scattering soot or soaking the seeds in brimstone, even an ingenious but impracticable " fly-trap " were suggested. Some of these methods doubtless decreased the damage but Rigby, writing in 1819, that is, after two generations of experiment, could still say that the turnip crop, " though highly important, has hitherto been considered as very uncertain," partly through drought but also because of the fly which " not infrequently sweeps away whole and repeatedly sown crops."

There was, therefore, sound reason in the view of Wimpey who in 1787 dismissed the endless suggestions as " inadequate for the purpose " and regarded " the invigoration and promotion of the growth of the plant " as the sole effective way of beating the fly. At any rate, he had the support of the labourers, shrewd and pessimistic as usual, whose opinion is presumably summed up in the traditional Wiltshire song,

" For the fly, the fly, the fly be on the turmut
And it's all me eye for we to try
To keep fly off the turmut."

The seriousness of the position appears in the Rev. H. P. Stacy's pamphlet of 1800 in which he recalls the failure or destruction of the turnip crop in the dry summer and severe winter of 1794 which compelled many farmers " to fodder their flocks with hay instead of turneps

and others to sell it before it was full fed." Thus the failure of the turnip crop meant a return to mediaeval conditions.

Now, the mangold can be regarded as a bigger and better turnip with a higher dry matter content per pound and a larger tonnage per acre. But above all it is immune from the fly while its own pests are far less destructive. It therefore answered a very real need of the British farmer. Yet the story of its introduction illustrates in striking fashion many of the characteristics of the Agricultural Revolution ; the importance of the " amateur " who did not depend directly for his living on the cultivation of his land ; the localised and haphazard introduction and slow spread of new methods from the scattered centres of the New Farming ; and the immense gulf between available knowledge and general practice.

The first mangold seeds to enter this country, two pounds in all, reached Sir Richard Jebb, a fashionable physician, in 1786, being sent from Metz by T. B. Parkyns. A covering letter explained that this root had recently been introduced to that district from Germany by an " experienced cultivator " at a time when hay and other fodder was scarce. The leaves, it seems, were valued as much as the roots and were so relished by cattle that samples were sent to the French Government which distributed 1,000 lb. of seed to the provinces. But they ordered these things differently in England. The new crop was neither welcomed by " experienced cultivators " nor encouraged by the Government.

Jebb presented some of the seeds to the Society of Arts and they were distributed to various members, including Dr. J. C. Lettsom, a Quaker philanthropist of wide interests, who raised some of the plants and ate the leaves and small roots. Shortly afterwards, he translated from the French and published the Abbé Commerell's book on the new vegetable. The interest aroused must have been considerable, four editions were sold in two years and the translator received seven hundred letters and two thousand four hundred requests for seed. But so far the main emphasis was on human consumption. The Abbé certainly appreciated its value as cattle-food but was clearly preoccupied with its importance as human food, particularly in times of dearth. Similarly, Lettsom expressly mentioned he could not confirm the Abbé's remarks on its value for stock and adds that the majority of letters he received from landowners, clergy and parish overseers dealt with it as a possible source of human nourishment, particularly of, course, for the poor. Those who tried it compared its leaves with spinach but found the roots " mawkish " and unpalatable, though as late as 1817 Pettigrew could still regard it as " an important addition to our list of culinary vegetables " as well as " a plant of value for feeding and fattening of cattle." It was in fact, some time before our farming forefathers appreciated the full worth of their new crop.

It must be remembered, of course, that the men of the time were entirely ignorant of its qualities. Thus Commerell points out that it did not appear in the botanical books and there was not even a French word for it, except an erroneously literal translation from the German, *mangold*, beet, being confused with *mangel*, dearth, whence the old name *la racine de disette* or " root of scarcity." So in 1789 Sir Thomas Darrant thought it was a perennial and the original methods of cultivation were not always the most efficient. Seed was sometimes set and sometimes drilled but the usual procedure appears to have been the costly and wasteful transplanting, while seed from bad strains sometimes produced unsatisfactory plants " with crowns close to the ground and long forked roots " instead of convenient plants " riding above the surface of the soil." Then there was the question of storage and many besides Sir Thomas Beevor must have found straw an inadequate protection in times of frost.

Further, the early emphasis on its unattractive culinary possibilities can hardly have encouraged the layman, while it was long before bought seeds were reliable. Thus in 1788 all the seeds Sir Mordaunt Martin purchased proved to be beet and he was compelled to buy

others from Brussels: in the following year Wimpey wrote cheerfully that "as I did not procure any seed from a seedshop but from an acquaintance of Dr. Lettsom's I suppose they were genuine"; and even in 1820 Rigby expressed no surprise at the failure of his purchased seeds. At first, too, the temporarily toxic qualities of the mangold after harvesting were not realised. In 1790 Sir Mordaunt Martin lost two cows apparently for this reason though he attributed it to dirt on the roots and he does not appear to have been the only sufferer from this curious defect, for it was this which biased Coke against the mangold. There were, therefore, concrete grounds for "the prejudice of ninety-nine people out of a hundred I have met" against the new crop which Sir Mordaunt Martin bemoaned in 1790.

There was, of course, at that time neither Rothamstead, the R.A.S.E. nor Cirencester to examine, report and instruct on such new crops and neither the Board of Agriculture, established in 1793, nor the only experimental farm in the country, a ten acre plot run by the Bath and West, were competent for the task. The future of the mangold, therefore, lay entirely in private hands and experiments were on a purely personal basis, results being discussed in private correspondence or the publications of local societies. The public-spirited men who championed it were few, Dr. Lettsom who experimented on a small plot near London, Sir Thomas Beavor of Hathel Hall, Sir Mordaunt Martin of Burnham and Dr. Rigby of Norwich, all three Norfolk men, and Joseph Wimpey of North Bockhampton being the most prominent. Their enthusiasm contrasted painfully with the apathy and ignorance of most practical farmers.

These pioneers, however, soon realised the value of the new crop as cattle-feed. As early as 1789 and 1790 Knapp and Wimpey were praising it and Bromwich of Cliff House, near Bridgnorth, found that it fattened stock more quickly than potatoes and, unlike turnips, did not taint milk, while Anderson, otherwise unenthusiastic, and Sir Mordaunt Martin emphasised its immunity from the fly. Yet there were but few converts and those mostly of the leisured type who did not farm for their daily bread and could be induced to try the new crop over a friendly glass of port or during a Sunday afternoon's stroll round a neighbour's yards. In 1791, for instance, Coke, "who had hitherto laughed at mangel-wurzel," agreed to try it after pulling and carrying a heavy root and there are references to the planting of mangolds by Lord Orford at Barton Mills in Suffolk, Mr. Dashwood at Cley in Norfolk, Sir William Lee at Hartwell and the Marquis of Salisbury in Hertfordshire.

More typical, it seems, was Sir Mordaunt Martin's experiment with two local farmers, "known to be no friends to novel practices," who were persuaded to watch cattle preferring mangolds to potatoes, for he does not mention any change in their views or methods. So in 1790 Wimpey could record regretfully that "not one farmer in a thousand has heard of it" and in 1792 the editor of the *Correspondence of the Bath and West* concluded that "but little expectation of the publick importance of the mangel-wurzel is now formed." Nine years later the indomitable Sir Mordaunt Martin echoed this verdict sadly. "My being singular in its culture, as long as I am successful, rather encourages than depresses my zeal." Yet even he grew only four or five acres and it is clear from the magnificent series of Board of Agriculture *County Reports* that the acreage and importance of the crop were at that time negligible.

Nevertheless the mangold *is* a useful crop and facts are as stubborn as and more enduring than prejudices. Further, it was a time when national needs and high prices were forcing progress on the farmer. So, though the incoherence of the Agricultural Revolution is reflected in its records and the men of the time paid little attention to statistics, it would seem that somewhere between Trafalgar and Waterloo the mangold "lost its amateur status" and appeared in the fields of men whose living depended on their crops. Thus in 1814 Lettsom wrote to Sir Mordaunt Martin that "without your systematic support the mangel-

wurzel would in all probability have been lost to this country. . . It is now one of the most productive vegetables we possess." There is also mention at this time of a certain Stevenson of Hatfield, "the largest and most successful grower" of the mangold in the country, and Pettigrew could write in 1817 that "after a short time, it (the mangold) was almost universally neglected. . . . but lately it has revived to a considerable extent." In the same year Blaikie, Coke's agent, refers to a mangold field without comment and Rigby in 1820 mentions his four acres of the crop as if it were part of his normal rotation, though his neighbours took a less enlightened view. The latter writer adds elsewhere that nine acres of mangolds were grown in Regent's Park by a Mr. Jenkyns and were sold to the "keepers of cows in London," realising a profit of £600.

It seems, therefore, that by, say, 1815 the mangold had left "the period of origins" and could progress not as an experiment but as a crop, albeit a novel one. This view is supported by the interest seedsmen were beginning to take in it, for in 1814 Sir Mordaunt Martin, rejoicing at "having contributed so much to bringing it into demand," was supplying Mackay's Nursery in Norwich and there was also apparently a merchant at Cambridge who stocked it. And once a novelty has been blessed by Commerce it can generally be taken as established for it has clearly come of an age to start business on its own.

NIGEL HARVEY.

13, St. Margaret's Road,
Oxford.

Bibliographical Note

The information in this article was taken from the following sources:—

An Account of the Culture and Use of the Mangel-Wurzel, translated from the French of the Abbé of Commerell by Dr. J. C. Lettsom, with an introduction, 4th edition, 1788.

Observations on the Failure of the Turnep Crop, by the Rev. H. P. Stacy, 1800.

Correspondence of the Bath and West Society, Vols. I-VII.

Memoirs of the Life and Writings of the late John Coakley Lettsom, by T. J. Pettigrew, 3 vols., 1817.

Conversion of Arable to Pasture, by Francis Blaikie, 1817.

Holkham and its Agriculture, 3rd edition, in *The Pamphleteer*, Vol. XIII, pt. XXVI, 1819, by Dr. E. Rigby.

Framingham and its Agriculture, by Dr. E. Rigby, 1820.

Board of Agriculture series of *County Reports*.

The writer was unfortunately unable to consult the following rare publications:

Suggestions for an improved and extended Cultivation of the Mangel-Wurzel, by Dr. E. Rigby, 1815.

Beta Depicta, by Thomas Newby, 1828.

SOME IMPRESSIONS OF SWEDEN'S NATIONAL AGRICULTURAL SHOW AND OF SWEDISH AGRICULTURE

SWEDEN'S National Agricultural Show may be regarded as comparable with England's Royal Show in that it is the premier show of the country and aims at providing a cross section of all that is best in farming practice and of the country's domestic live stock. In one important respect, however, it differs from the "Royal," for it is held at infrequent intervals and not annually. It is 100 years since the first Swedish farm exhibition was held, and 15 years since the previous national show. The show which opened at Solvalla, Stockholm, on the 8th June, 1946, being in the nature of a centenary, was marked by special arrangements and by the presence of many foreign representatives. The British delegation included the Rt. Hon. Tom Williams, M.P., Minister of Agriculture, who headed the delegation, Sir Donald Vandepeer (Permanent Secretary to the Ministry), Sir Patrick Laird (Secretary to the Department of Agriculture for Scotland), Mr. James Turner (President, National Farmers' Union), Mr. Anthony Hurd, M.P., and myself, representing the Royal Agricultural Society of England.

Although the Show was formally opened to the public on Saturday, June 8th by H.M. the King of Sweden, all the stock had been judged on conformation on the two days previous to the opening, while performance records on which the awards also depended had been calculated up to May 1st. In some cases the necessary computations came very considerably before the data were ready for the judges of type and conformation. Attached to the pen or stand of each exhibit was a card giving precise information, including name and particulars, Herd Book No., date of birth, pedigree, and certain information regarding the performance of parents and grand-parents, *e.g.*, sire's pedigree value and performance of the dam, details of awards made by judges of conformation and, where appropriate, the utility value of progeny are also included.

The Show continued for nine days so that most exhibitors could reckon on having their stock absent from home for at least a fortnight. It is partly because of this that such a show is held only occasionally; and of course the expense and trouble involved are considerable. Sweden is a big country, with a total population only about half of that of London. However, if some Swedish agriculturists think that even once in fifteen years is too often, or that a national show is too ambitious an undertaking anyway, there are others who feel that ten-yearly intervals would be preferable. Since the previous National Show five fairly big district shows had been held, these being of four or five days' duration, with performance tests as a condition of entry.

Policy governing the National Show, including such fundamental details as its size and character, is controlled by the Royal Board of Agriculture—but only after the State has influenced the Board's decision through its financial vote.

During the first three days at Solvalla 100,000 people attended. Ultimately more than 300,000 passed through the turnstiles. Admission charges were the equivalent of 6/- for the first and second days, 4/6d. for the third day and 3/6d. for all other days except the last, for which admission was 2/6d. About 2,000 people could be accommodated in the ring grand-stand, for which a special charge equal to 2/6d. was made for each of two sessions a day.

Entry fees for livestock were as follow (1 Swedish Krone reckoned at approximately 1/3d.) :—

Horse and foal	40 kr.
Horse	60 kr.
Bull	15 kr.
Cow	10 kr.
Pig	20 kr.
Sheep and Goat	10 kr.
Sheep-dog	10 kr.

All animals entered for the show were inspected and approved for exhibition by the equivalent of our Ministry of Agriculture Live Stock Officers, and all therefore received a premium which, in the case of pigs, varied from £3 15s. 0d. to £9. There were, of course, additional prizes and trophies based on conformation and on a combination of performance and conformation. (The essential difference between the Swedish and the British method of awarding prizes is that not merely a few animals in each class are recognised : all get something on the basis of attainment of a minimum standard). Dual-judging of conformation and type prevailed, with a referee available in each section. Championship and group prizes were awarded by Government specialists.

Breeders look to the national show to sell animals privately. Auction sales for breeding stock are common in Sweden but are not held at the Show.

Of the live stock entries 469 were horses, 383 cattle, 312 pigs, 211 sheep, 7 sheep-dogs, 300 poultry and 168 rabbits.

Breeds and types of horses included Thoroughbreds, Belgians, Oldenburg, and a splendid entry of the North Swedish breed, a lightish-weight horse which is used largely for lumber work ; it appears to be increasing in popularity, partly because of its making lighter demands on fodder. The Swedes are horse-minded. Pride of turn-out is reflected in the smartness not only of the horses, but also of the grooms. As in some other European countries, the parade in the ring is an occasion for showmanship ; grooms appear in smart semi-uniforms, often with coloured caps. (Incidentally the liking for gay colour—especially scarlets—is as pronounced in the country as in the city).

There are three breeds of cattle in Sweden : all were strongly represented. The Swedish Red-and-White (S.R.B.) is the most popular and may be regarded as the national breed. With a strong admixture of Ayrshire and Shorthorn in its make-up, it compares very favourably with the best of our red-and-white Dairy Shorthorns. Type has been fixed by intensive line- and in-breeding. There is some talk of introducing more Shorthorns, fresh blood being necessary to improve certain breeding qualities which have tended to deteriorate. The average milk-yield of the Swedish Red may be taken to be about 4,000 kilogrammes (850 gallons) in 365 days, with an average of 4 per cent. butterfat.

Next in popularity to the S.R.B. is the Swedish Lowland Breed (S.L.B.), black-and-white cattle comparable with the Friesian. Kept mostly in the south, the average milk-yield is higher than that of the other breeds, being approximately 4,500 kilogrammes (990 gallons), averaging 3.8—3.9 per cent. butterfat.

Very attractive and commercially-sound cattle are the Polled S.K.B. They can be white, or white-flecked-with-black, or a pale-red. About ten years ago the two types—the white and the red—fused to become one breed ; but apparently they are not crossed, so that there are still two distinct types. They are kept mostly in the North, especially in mountainous districts, and have been influenced by the Norwegian mountain breed. About the size (and having the " quality " appearance) of a Jersey, the S.K.B. impressed me very favourably, this finding support in their performance—a yield of an average of 3,500 kilograms (770 gallons) with 4.5 per cent. butterfat.

There is no Swedish beef breed ; indeed there are practically no beef cattle at all. A few Aberdeen-Angus have been introduced and a small group were seen at the show, but they could hardly be regarded as representative.

The two breeds of pigs, Yorkshire (Large White) and Landrace were represented in force. The Yorkshire, founded and maintained on English stock, is about as popular as the native breed. Crossing of the two is extensively practised. Both breeds have infusions of fresh blood from time to time, the one from England and the other from Denmark. It is noteworthy that the supreme champion Large White boar at Solvalla was imported from England in 1942. At 8 years old the boar is still regarded as one of the best of the breed used in Sweden ; and this opinion is based not merely on his appearance, but also on the performance of his progeny. Swedish pig-breeders are able to test the validity of personal preference : performance records based on carefully controlled tests are a feature of their breed improvement work.

Sheep are kept in Sweden chiefly, if not wholly, for their wool. The breeds represented at the show were the Swedish Landrace, Lincoln Long Wool, Leicester, Cheviot, Shropshire and Oxford Down, with crosses of the Leicester-Landrace. Most popular nationally is the Swedish Landrace, a smallish sheep. Even sheep have to qualify for the right to be exhibited at the national show, the standard being the texture and quality of wool. They have also to be approved before admission into their Flock Book.

The site of the showyard being a race-course, advantage could be taken of extensive permanent buildings as well as of made-up roads and of two large and well-equipped restaurants. A ready-made site invariably has its drawbacks ; this was no exception. Without permanent grass, the state of the light sandy soil after two days' trampling can be imagined. Dust began to make conditions as unpleasant as mud would have done had the rain on the second day persisted. (Sleeper-roads were perhaps unnecessary). A hard road ran from one end of the ground to the other. Machinery was arranged rather more according to its purpose than to its factory-origin, which has much to commend it from the point of view of the spectator, whatever may be the objections. A good deal of the machinery-in-motion was in the open.

Apart from a potato-harvester which, with the aid of rubber bands fitted to segregate stones, performed the entire operation from digging to bagging, there seemed to be nothing revolutionary. A sugar beet lifter which loaded the beet direct to a lorry in the field was the result of much experimental work. It appeared to have overcome many objections of prototypes and created something of a stir. Most of the machinery bore comparison with our own as to type and purpose ; much of it was American. A Fordson and a David Brown tractor were the only British products that I saw and these, alas, were not in the parade of implements and machinery, which proved to be a particularly interesting feature of the ring-programme.

The ring itself and every inch of space around it was packed with spectators to receive the King on his arrival for the formal opening. Escorted by household cavalry and accompanied by many members of the Royal family, his Majesty received a warm welcome. Although 88 years of age he spoke with remarkable vigour. His contact with the farmers was felt to be direct and intimate. A great concourse of farmers and their families assembled in the arena to receive him. Each group had its Standard Bearer and the inevitable Swedish flag. After the King had addressed those present the farmers' leaders made their homage from a small platform placed in front of the Royal Box. The speeches concluded, the farmers and their families paraded in military order past the Royal Box. Leaders of each group dipped their flags in salute to the King. It was a singularly impressive spectacle and one which lost nothing in focussing attention upon the importance of farming to the life of the nation.

The parade of stock that followed was carried through with commendable efficiency and effect. There was no assembly of prizewinners as at the "Royal," but the winners in the cattle, horse, and sheep-dog sections entered the ring at one end and passed straight across to an exit at the other end, accompanied by a running-commentary. Female prize-winners in each class entered in line abreast. There followed one of the most interesting and instructive items of the programme: a parade of tractors and implements, including varieties of the combine harvester, drills, potato lifters, harvesting equipment and even a mole drainer. Everyone enjoyed the innovation, not least the drivers, some of whom emulated the grooms in being smartly turned out in uniform. A running commentary provided just the background necessary to satisfy the curiosity of many spectators.

At a second visit I examined the layout and construction of shedding which, when studied in detail, proved interesting, even if, judged by British conditions of timber supply, an impression of extravagance in its use was inevitable While it may be that neither the shedding nor construction provided much that was new to us, they were effective. Canvas being in short supply, a species of cardboard was used for roofing; and angle-iron struts at six-foot intervals in the framework of shedding furnished food for thought. Photographs were obtained of the type of shedding used, including interior layout, and also of a very useful and simply constructed type of seat for visitors. Some of the shedding appeared to be rather flimsy, but it has to be remembered that the same timber is not used in successive years as at the "Royal" and also constructional work would be started much later in the year. Most of the cattle were rugged-up. The docility of the bulls was noticeable; indeed it may be said that although most of the stock appeared to be very much in natural condition this may have been due largely to shortage of food. They were however obviously well cared for and therefore reflected a high standard of management and sympathetic handling.

Apart from the show a very full programme had been prepared by Mr. Miles de Wachenfelt, Agricultural Counsellor to the Swedish Legation in London, whose consideration and hospitality knew no bounds.

An appropriate commencement was a visit to the Milk Central—the Farmers' Co-operative Dairy Association—at Stockholm. This co-operative Association is owned by 27,000 farmers of central Sweden, directed by a board of seven farmer members. The average number of cows owned by each member is eight. Milk is collected and then delivered to one of 61 dairies to be pastuerised for consumption and processing. The net proceeds of sales are pooled among members.

Swedes like milk. The average consumption per head of the population of Stockholm is about one gallon a week (under normal conditions about the highest *per capita* consumption in the world) which compares with the two pints in England in winter. The Milk Central's Dairy products, apart from milk, include butter, cheeses, sterilised cream, ice-cream, sour milk, butter-milk and yoghourt. In 1944 this single organisation collected 1,200,000 lbs. of milk while 44,000,000 lbs. of butter and nearly 9,000,000 lbs. of cheese were manufactured.

At the Association's office the delegation was given a brief survey of Swedish agriculture and of the co-operative movement.

Fifteen per cent. of Sweden, we were told, lies within the Polar Circle; but the climate being influenced by the Gulf Stream is therefore helpful to profitable farming. The arable area of the country reaches its greatest density in the south. Agriculture and forestry are mostly complementary. The division of the land into large and small holdings is more or less dependent upon natural conditions and social development. In the main occupiers are, and have always been, the owners themselves. Only about one-quarter of the total arable area and one-fifth of all agriculture holdings are occupied by tenants. The

average size of a Swedish farm, excluding the very small holdings, is about 9 hectares, the equivalent of $21\frac{1}{2}$ acres.

The agricultural population, which up to 1870 formed three-quarters of the total population, has since steadily decreased. It is now about one-third and a further decrease to about one-fourth of the total by 1950 is anticipated. Of the $1\frac{1}{2}$ million people engaged in agriculture about 90 per cent. conduct family farms.

The most far-reaching change which has taken place in Swedish agriculture in the past 100 years is the increased cultivation of fodder crops on arable land, and, in this connection, the introduction of a more scientific rotation of crops. Before the war about 11 per cent. of arable land was cultivated for winter cereals ; that is, winter wheat and rye. The area of spring cereals was 30 per cent. : roots 7 per cent. ; fodder-crops 45 per cent., 7 per cent. was fallowed. During the war the area of grain for direct consumption increased, as did the area of oil seeds, hemp and flax. Production per hectare is very high in Sweden and amounts for winter wheat, for example, to about 2,400 kg. per hectare, *i.e.*, about 18.8 cwt. per acre.

Conditions generally are favourable to animal husbandry, although the hard and difficult winters necessitate indoor feeding to a considerable extent. Costs of production have however been so reduced that Sweden has been able to compete successfully on the world market.

The number of cattle has steadily increased (with a setback during the war) and is now about 2.9 million of which 1.9 million are dairy cows. This is about the same number as before the war. The number of pigs has also progressively increased under normal conditions, but in recent years there has been a falling off so that at present the number is roughly 1 million head, or about 75 per cent. of the pre-war level. In contrast to cattle and pigs, the sheep population has been dwindling for a long time past, except for the periods of the two world wars. The number at present is only about 300,000.

Agricultural co-operation in Sweden is traditional. The history of the movement dates back to the '80's of last century. The idea was first incorporated in dairying and in the egg trade, when local societies were formed for the establishment of dairies, the manufacture of dairy products, and the marketing of eggs on behalf of their members. Later, in the '90's, the first local purchasing societies were founded, and in 1899 the first co-operative slaughter-house was established. In 1915 the first of the agricultural credit societies were formed, and in the early 1920's both forest owners and fruit growers commenced selling their products co-operatively.

The development of the agricultural co-operative movement in its present form has mainly been the work of the General Agricultural Society of Sweden, which has directed the organisation of the movement in recent years. The Society was founded in 1917 for the purpose of promoting the interests of Swedish agriculture. At first its members mainly consisted of individual farmers and agricultural societies. In the course of the years its work —mainly directed to economic questions—changed in some respects to meet new requirements, more especially those concerned with marketing.

In 1940 the Swedish "General" Agricultural Society was replaced by the Federation of Swedish Farmers' Associations. That meant that membership was no longer open to individual persons, but was restricted to agricultural associations of an accepted national standing. The original functions of the Federation were : (1) to put forward the agricultural point of view on questions of general national importance (2) to act on behalf of all the agricultural co-operative associations and (3) to arrange for close collaboration between agricultural co-operative and professional and industrial co-operative organisations.

In 1945 yet another re-organisation of the Federation took place. As a result it is

now possible for the Federation to carry out further activities of importance for the benefit of member-associations and farmers individually.

In 1944 the number of members of the primary organisations associated to the Federation was 994,300. The majority of Swedish farmers belong to three or four branch-organizations; that means that the number of organized farmers is about 350,000. Nearly all these are represented in the organizations. In addition, there are a number of very small holders in horticultural and market-gardening egg marketing organizations.

The branch organizations, which at present are members of the Federation, comprise Dairies, Meat Marketing, Purchasing and Selling, Egg Marketing, Forest-Owners, Bank-Credit, Mortgage Bank, Distillers, Beet-Growers, Fur Breeders, Starch Producers, Flax and Hemp Growers, Oil Plant Growers and the Union of Small-Holders.

The Swedish Farmers' Union is a separate organization.

The development of these huge organizations has been carried out by the farmers themselves; they are in no way dependent upon the Government. During the world economic depression and the second world war they were of great help to the Government.

The total value of the organised sale of products and purchase of farmers' requisites through co-operatives in 1944 represented over 90 per cent. of the estimated value of all agricultural products sold by farmers. The dairy organization is at present responsible for about 96 per cent. of all the milk passing over the weighbridge in the dairies, the meat marketing organization for 72 per cent. of all slaughterings brought to the market, and the grain marketing organization for 65 per cent. of the cereals offered for sale.

The latest link in the farmers' co-operative chain is a school at Sanga Saba. The aim of this is to promote farmer-co-operative ideas and to train young men for social and economic work in the agricultural field. We visited the school and had an opportunity to appreciate the breadth of outlook and efficiency of those responsible for the movement. We were received by the Principal and his senior lecturer. We were told that approximately one-third of the upkeep of the school is met by a State grant of about £1,700 a year; the balance comes from the Farmers' Co-operative Association. A beginning was made two years ago. Already 80 farmers and 30 officials have been trained there. In addition, about 1,000 students have taken short courses to give them knowledge and confidence and thereby to allow them to take part in the affairs of the movement. By and large the school aims at instructing farmers who may become chairmen of local co-operative societies, and men and women who intend to take up official posts in the co-operative movement. The full course of five months takes place during the winter. Only candidates having a practical knowledge of farming and who have worked in a co-operative organization are eligible. The syllabus includes Political Economy, Politics, History, Language and Book-keeping. The average age of students is 27. Short courses held during the summer range from one to two weeks. Work and recreation and the delightful surroundings in the country combine to suggest an ideal interlude to the rush of modern life, the more so if, as we were assured, the result is a wide view of co-operation without propaganda.

It was at the school that we became aware that one of the major problems which now engages attention in Sweden is how to deal with the large number of very small farms that cannot now pay their way as separate economic units. Something like 50 per cent. of all farms are from 2-10 hectare (5-25 acres): the desired optimum is a farm of 10-20 hectare (25-50 acres), but at present there are only about 14 per cent. of these. The Government's desire to see the very small holdings replaced by slightly larger units represents a reversal of State policy, for from 1910 to 1920 the distribution of land into very small lots was pursued as being best suited to economic stability.

In discussions about the Swedish dairy industry we learnt that farmers take skim-milk and whey from the dairies for stock-feeding as is the common practice in Denmark.

Butter and cheese manufacture are extensive largely because they provide the best means of regulating surpluses of milk. The basic price for milk is the same throughout the area covered by the Milk Central, with appropriate adjustments according to the situation of the farms.

To help keep down the cost of milk to the consumer a subsidy of 1 ore per litre of milk delivered is paid by the Government. We found that milk is distributed in Stockholm very largely through milk stores of which there are about 2,500 in the City. Mostly they are a sort of cross between the grocery and the dairy shop which used to be a feature of London. Housewives usually collect their milk at the store ; at the same time they can also buy various kinds of tinned food, bread, biscuits, fruit, ice-cream and cereals. The consumer population served in this way is about 800,000.

The price of milk paid to producers is fixed by negotiation between the Board of Agriculture and farmers. The selling price to consumers is a subject of legislation. Producers are paid on a quality basis, *i.e.*, on the fat content (minimum 3.5 per cent.), on cleanliness, and on keeping quality. Milk is sold to consumers on a 3 per cent. fat basis in order to provide cream for butter. Only 1½ per cent. of the milk in Sweden is tuberculin tested. The tendency is for all milk to be pasteurised.

Of the interesting functions we were privileged to attend one that stands out as particularly striking is the banquet given by the Board of the Royal Show at the Town Hall, Stockholm. Over 600 guests, including the Crown Prince and several other members of the Royal family, along with visitors from many foreign countries, attended. The beauty and dignity of the occasion and the setting of it in one of the finest buildings of its kind in the world were most impressive.

Another function deserving of special reference was that given by the Federation of Swedish Farmers' Associations, when the Chairman, Mr. Leidberg, made a remarkable speech, first in English, then in Norwegian, and finally in Finnish. The wisdom of his remarks will be obvious by the following quotations which I give in outline :—

> "You are", he said, "in a country which has escaped the horrors and destruction of war. We are grateful to the fate which has allowed us to live in peace.
>
> "May the immense sacrifices have as their result peace—and abiding peace, not only armistice—a peace which mankind is longing for, praying for and undoubtedly needs.
>
> "Peace means friendship between nations. Peace means ever-increasing intercourse, personal contacts, exchange of goods and services. May this informal meeting be a contribution, however small, to unite us.
>
> "Peace means that countries with less favourable conditions for agricultural production but which, in times of war, have turned to agriculture for succour, have relied upon and enjoyed cheap foods from countries having cheap labour. This may soon be the problem of Sweden.
>
> "The agricultural show aims at encouraging rationalization, *i.e.*, to secure the best results from the soil, from capital and from labour ; and secondly to reflect the work of the agricultural co-operative movement which unites farmers' private enterprise to centralization and co-operative action. We rely on the Government and the political parties to decide the degree and nature of the protection—particularly the protection against external superior competition and the ruinous prices—which farming gets.
>
> "We do not want protection to serve private ends. We are dependent on a large export of industrial products and a corresponding import of essential goods. But in agriculture the conditions make some protection inevitable. Is this necessary ? Has mankind as a whole—even apart from the post-war famine—ever had enough to eat ? Has the world as a whole ever had an over-production of food ? Does the

world as a whole profit by the fact that the biggest proportion of mankind consists of low-paid producers of food with miserable purchasing power and poor possibilities of consumption ? Definitely not, in my opinion.

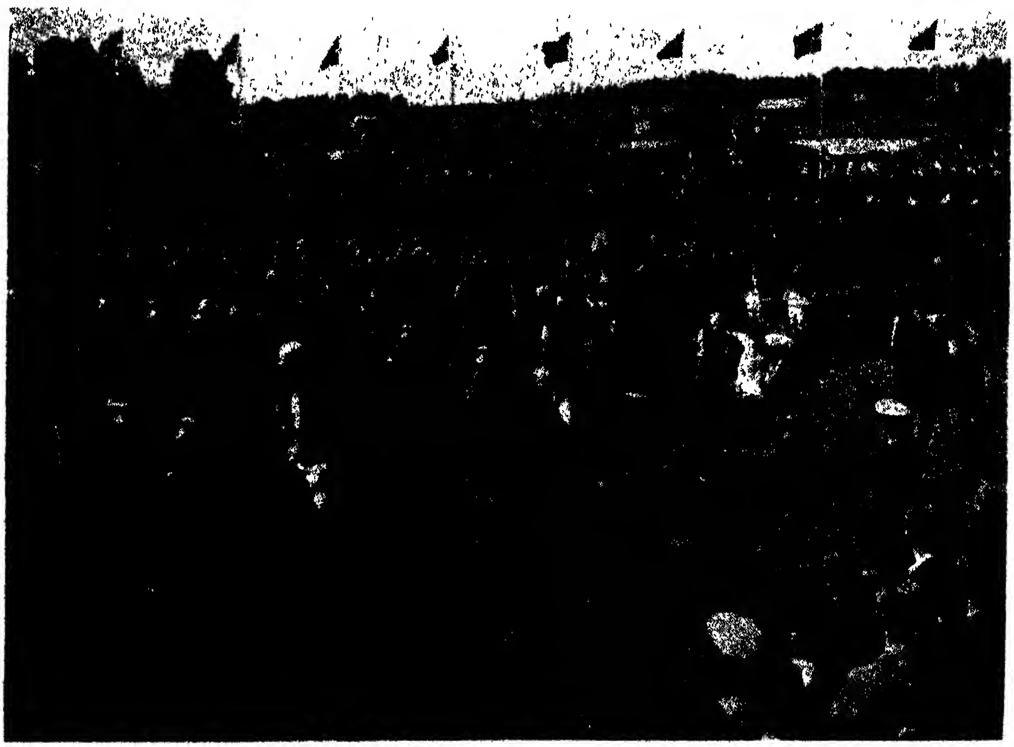
"Effective improvement must involve fundamental structural changes both nationally and internationally. *We* are not likely to live to see the ideal world. But someone must start and the sooner the better.

"British, Danes, Finns, Norwegians or whatever you are, together with us you are also farmers with essentially common interests. Professional co-operation across the boundaries of countries ought not to be incompatible with patriotic duties. A common endeavour to keep a sound trade exchange between agricultural products and other products and services ought to be of advantage to all and to the disadvantage of none. In the long run a general depreciation or partial dumping can only lead to decline of trade and ruin.

"I allow myself to hope that we might be able to find ways and means, more active than a dinner-speech, to help each other, to support each other and to co-operate our endeavours.

"I propose a toast for the happy future of agriculture everywhere and for the happiness and prosperity of the people who now cultivate the land of our forefathers and who will in future carry on our work."

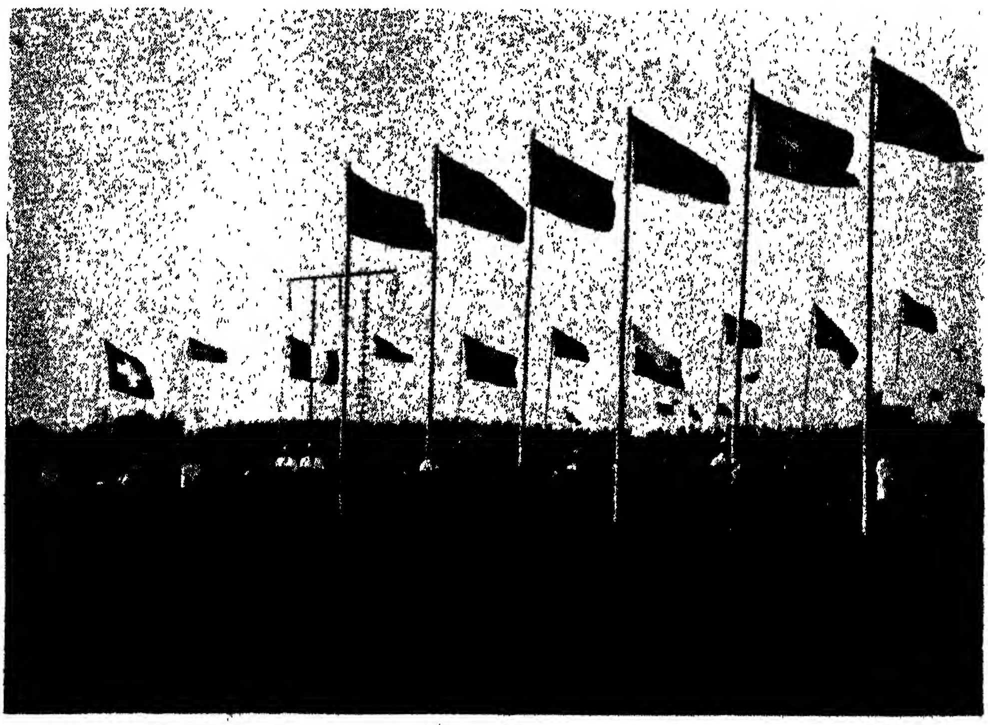
Perhaps I may be allowed to record that our Minister of Agriculture, Mr. Tom Williams, made an entirely effective and impressive impromptu response ; and that Mr. James Turner was not slow to seize the opportunity of both telling the company about the international conference on agriculture and issuing an invitation to Sweden to co-operate.



ARRIVAL OF THE KING OF SWEDEN

We were fortunate to get to know something of Professor Bonnier's classic work on monozygous or identical twins in cattle. " Monozygous " means from one fertilized egg and identical twins are the result of the early splitting of the egg. Each member of the twin pair is identical, *i.e.*, carries an identical set of hereditary factors. This kind of material is ideal for the research worker and can be used for a great variety of experiments on feeding and environment. In the ordinary way large numbers of animals in groups have to be used because of the fact that the animals are unlike in their heredity and that this difference confuses the result of, say, the feeding experiment. Professor Bonnier calculates that with 9 pairs of identical twins he can achieve a degree of accuracy for which, with unrelated cattle, he would need 360 animals on the experiment.

The first experiment with these identical twins was started in 1941 and was designed to examine the effect of a high plane of nutrition *v.* a low plane on growth in relation to food consumed up to 27 months of age. There are, of course, striking differences between the high plane and low plane member of each pair, although it is by no means certain that the high plane of nutrition is an economic one. But of even greater interest is the difference in food utilization between the unrelated pairs of identical twins. From the statistics of food consumed, which were kept most accurately, it is clear that an inherited capacity for growth is a very real thing and that some animals grow very much more efficiently, *i.e.*, with much less food, than do others. Throughout its life every animal has a maximum capacity for growth determined by its genetic or hereditary make-up, and the differences in the amount of this capacity and the efficiency with which it is attained which are now being revealed by Professor Bonnier's identical twins suggest that in the future we will pay much more attention to this factor in developing our strains of livestock.



CATTLE PARADE

All identical twin heifers calve down at approximately the same age and equally interesting experiments on the effect of plane of nutrition and the efficiency of food utilization on milk production are now being studied. There appears to be a close connection between the efficiency of food utilization for milk and efficiency of food conversion during growth by the same animal, although it is yet too early to say if, by measuring the latter, one can predict the former.

Our interest was at once aroused by the methods practised to determine true twinning. Tests comprised comparisons of colour; marking; hair-whirls; sections of hair; size; position and colour of eyes; colour and print of muzzles; shape of udders, and shape of ears. The similarity of the muzzle-prints of natural twins is remarkable. We were told that a detailed similarity between the muzzle prints of the two members of a monozyous twin pair will never be found as these prints are influenced by the intra-uterine environments as well as by external environment.

Swedish dairy farmers now know pretty much the kind of material which Professor Bonnier wants and an increasing number of identical twins are being put on offer to his research institution. The frequency of identical twinning in cattle is not nearly as high as it is in man, but it has been calculated that, out of a dairy cattle population of approximately 1½ million cows, 1,600 pairs of identical twins are born each year. In England the number is likely to be about double this figure and there is obviously plenty of material available to our research workers when they decide to make use of it.

It will be appreciated that this report is but an outline of the more significant and interesting features of our visit. Our Swedish hosts could not have been kinder, or more hospitable. For so much we are indebted to Mr. de Wachenfelt, to whom the thanks not only of the delegation but of the whole British farming community generally are due. He spared nothing to give all that was interesting and profitable to the success of the visit. His erstwhile lieutenant in London, Herr Thure von Eckermann and his wife, were also kindness itself. And a special word of thanks and tribute is due to the British Minister and his Commercial Counsellor, Mr. H. L. Setchell, C.B.E., who went so far out of his way to provide arrangements for our well-being and comfort both at Stockholm and for the return journey. To these and all who helped I, like the others of our party, am deeply grateful. I can only hope that we in Britain may have an opportunity to reciprocate.

ALEC HOBSON.

SECRETARY,

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

SEEDS MIXTURE TRIALS

THE AGRONOMIC BEHAVIOUR OF INDIVIDUAL SPECIES AND STRAINS.

THE series of trials upon which this article is based were first started in 1937 as the outcome of grants made by the Royal Agricultural Society of England to the Welsh Plant Breeding Station. Further centres were established under these grants in 1938 and again in 1939—40. When the Grassland Improvement Station was established in 1940, the number of trial centres was greatly extended throughout the English counties and these trials were thereafter financed by the Ministry of Agriculture and Fisheries. The whole series of trials has been continued in subsequent years, up to and including 1946, as an important part of the extra-mural work of the Grassland Improvement Station.

In 1944, however, by means of a special grant of £1,000 contributed by the R.A.S.E. to the Grassland Improvement Station, another series of Animal Production Trials was initiated in a number of English counties. Subsequent trials in this latter series were established in 1945/46 and financed by the Minister of Agriculture through the Station. In connection with all these trials, therefore, we would pay a tribute to the initiative and continued support given by the R.A.S.E. to grassland investigational work in Britain. In these days of extending State control it is wholly inspiring to know and to realise that we, in Britain, can still retain and exercise our right to support research projects over a wide field of activity. In the present instance, the initiation of the grassland trials under review was wholly to the credit of an independent organisation—the R.A.S.E. Following up this initiation, the State made its equally valuable contribution by giving its extended support to the projects already started (the early trials were financed 1937-1940 by R.A.S.E. and 1940-1946 by Government). Then in 1944 the new series of Animal Production trials was started by the Society and financed by them in 1944-45. Again Government has made its contribution by financing the Animal Production trials during 1945/46. Thus, we have here a characteristic instance of our traditional British way of doing things and an excellent example of a successful co-operative effort between State and private enterprise.

The present report deals with sowings made from 1937 to 1943, but no further reference is herein made to the Animal Production Trials 1944/46. An initial account, relating to some of the earlier trials (1937 to 1941) has already been published in this *Journal* (Vol. 103, 1942). This dealt chiefly with establishment in relation to reseeding under contrasting conditions in different parts of the country. The present data offer scope for assessment of persistency in the various components used in the seeds mixtures and with particular reference to the agronomic reaction of contrasting strains of the grasses and clovers so employed. The data available, as a result of these studies, also provide valuable evidence relative to the competitive ability of the different constituents used in seeds mixtures and all in relation to contrasting conditions of soil, climate and grassland management.

MATERIAL AND METHODS.

In the series 1937 to 1943 inclusive, sowings were made at upward of two hundred centres, representing conditions throughout England. The normal procedure has been to plan each series of mixtures on the basis of five one-acre plots at each centre. The trial centres were normally placed on private farms and occasionally on lands in occupation of W.A.E.C.'s. The seeds mixtures were planned by the Station and the lots prepared and despatched ready for sowing to the various trial centres. The whole scheme was conducted throughout in the closest co-operation with the technical staffs in the counties, who have

frequently gone to great pains to supervise the trials locally. Members of the Station staff have visited the individual centres from time to time and botanical analyses have been conducted at a large proportion of the centres. It has been the general aim to make detailed botanical readings at as many centres as possible in the first, third and fifth harvest years. In some instances it has been possible to take readings in the intervening harvest years as well. Whenever a centre was visited, detailed field notes were made on it in relation to sward development and as to current grassland management.

The method used in botanical analysis throughout the series of trials has normally been that of percentage area. This method provides a good picture relative to general characteristics of the sward and is particularly useful in presenting a comparative statement relative to sward development from year to year. It does not, of course, provide data relative to productivity, and it has not been possible in the present series to assess comparative production as between different mixtures. The present trials are therefore designed to assess broadly the comparative development and sward-forming attributes of the various species and strains employed in the mixtures, and to do this over the widest possible range of conditions throughout the country. The data that have been accumulated serve to present a sound general picture of the comparative persistency and competitive ability of the different strains when grown in mixtures under normal farm conditions.

THE SEEDS MIXTURES.

Throughout the whole series, the type of seeds mixture employed has been one designed to cater for medium to long duration leys, that is, for leys of a *minimum* period of three years. The majority of the mixtures would be suitable for the production of swards of quite long duration. There has been no attempt at complete standardization in the details of the seeds mixtures. The general plan, followed in most seasons, has been to design simple mixtures along lines as follows :—

(*a*) ultra-simple ryegrass with clover.
(*b*) ultra-simple cocksfoot with clover.
(*c*) ryegrass and cocksfoot with clover.
(*d*) ryegrass and timothy with clover.
(*e*) ryegrass, cocksfoot and timothy with clover.
(*f*) ryegrass, timothy and meadow fescue with clover.

In more recent years, mixtures based on timothy and meadow fescue have been used at certain centres, while still more recently a comprehensive series of lucerne trials has been established. The general problems of rate and date of sowing are also being investigated. Other trials within the general scheme of extra-mural experiments have been designed to test certain grasses, clovers and medics of overseas origin. For example, such grasses as *Phalaris tuberosa* and *Bromus inermis* are bring tried, while among the legumes there have been extensive tests with subterranean clover and with certain species of *Medicago* from Australia. The results from these latter trials will form the subject of a separate report.

Throughout the whole series, an attempt has been made to test the comparative value of the different strains of grasses and clovers used in the mixtures. In a few cases, notably in the 1941 trials, different type-mixtures were under test, but in most instances, the mixtures at a given centre have been broadly similar to each other, differing only in the strains used in the several plots.

In the first series of trials, sown in 1937, two mixtures were employed : one composed entirely of commercial strains while the other contained the same species but differed in that a proportion of bred strains were sown. In the 1937 series, mixtures of bred strains of perennial ryegrass were used at all centres and of cocksfoot at some centres. Direct comparison of the behaviour of individual strains was not possible, therefore, but only the gross

TABLE I.

Seeds mixtures sown in 1940, 1942 and 1943.

YEAR SOWN	1940.					1942.						1942.					1943.					1943.				
TYPE OF MIXTURES AND STRAINS	Perennial ryegrass strains.					Perennial ryegrass and cocksfoot strains.						Perennial ryegrass and timothy strains.					Perennial ryegrass and cocksfoot strains.					Perennial ryegrass and timothy strains.				
MIXTURE NOS.	I	II	III	IV	V	I	II	III	IV	V	Va	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
Italian ryegrass: Irish	8	8	8	8	8	6	6	6	–	6	–	8	8	8	8	8	–	–	–	–	–	–	–	–	–	–
Italian ryegrass: N.Z. cert. m.s.*	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	6	6	6	6	–	6	6	6	6	–
Italian ryegrass: N.Z. cert. p.s.†	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	6	–	–	–	–	6
Perennial ryegrass, Irish	16	–	–	12	8	16	–	–	–	4	–	16	–	–	10	10	16	–	–	–	–	16	–	–	–	–
do. do. N.Z. cert. m.s.*	–	–	–	–	–	–	–	–	16	–	–	–	–	16	–	–	–	–	–	16	–	–	–	–	16	
do. do. N.Z. cert. p.s.†	–	–	–	–	–	–	–	–	–	–	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
do. do. S 24 (leafy hay type)	–	–	16	–	–	–	16	–	–	8	–	–	16	–	–	–	–	16	–	–	–	–	16	–	–	–
do. do. S 23 (pasture type)	–	16	–	4	8	–	–	16	–	4	–	–	–	–	6	6	–	–	16	–	–	–	–	16	–	
N.Z. "Short Rotation ryegrass" (H.I.)	–	–	–	–	–	–	–	–	–	–	–						–	–	–	–	16	–	–	–	–	16
Cocksfoot U.S.A.						6	–	–	–	2	–						6	–	–	–	–					
do. N.Z. cert. m.s.*						–	–	–	6	–	–						–	–	–	6	–					
do. N.Z. cert. C.23						–	–	–	–	–	6						–	–	–	–	6					
do. S 37 (leafy hay type)						–	6	–	–	2	–						–	–	–	–	–					
do. S.143 (mop pasture type)						–	–	6	–	2	–						–	6	6	–	–					
Timothy, U.S.A.	3	3	3	3	3							6	6	6	–	–						8	–	–	–	–
do. S.51 (leafy hay type)	4	4	4	4	4							–	–	–	6	–						–	8	–	–	–
do. S.48 (pasture-hay type)	–	–	–	–	–							–	–	–	–	6						–	–	8	8	–
do. N.Z.	–	–	–	–	–							–	–	–	–	–						–	–	–	–	8
Rough stalked meadow grass	1	1	1	1	1							–	–	–	–	–						–	–	–	–	–
Red clover, English Broad Red						4	–	–	–	2	–	4	–	–	2	–	4	–	–	–	–	4	–	–	–	–
do. American Mammoth						–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
do. English late flowering						–	–	–	–	–	–	–	4	4	–	–	–	–	–	–	–	–	–	–	–	–
do. Cotswold late flowering						–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	4	–	–	–
do. S 123 extra L.F.R.	–	3	3	3	3	–	–	4	–	2	–	–	–	–	2	4	–	–	4	–	–		–	4	–	–
do. N.Z. c m.s.* Montgomery	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	4	4
do. N.Z. c.p.s.† Montgomery	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
do. Montgomery L.F.R.	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
White clover, N.Z. uncertified	–	–	–	–	–	1	–	–	–	½	–	1	–	–	–	–	1	–	–	–	–	1	–	–	–	–
do. S.100	2	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	1	–	–	–
do. Kent Wild	–	2	2	2	2	–	–	1	–	¼	–	–	–	–	–	1	–	–	1	–	–	–	–	1	–	–
do. N.Z. cert. m.s.*						–	–	–	1	–	–	–	–	–	1	–	–	–	–	1	1	–	–	–	1	1
do. N.Z. cert. p.s.†						–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
do. N.Z. cert p.p.s ††						–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Trefoil						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Alsike						2	2	2	2	2	2	2	2	2	2	2	–	–	–	–	–	–	–	–	–	–
Subterranean clover (mid-season)						–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–
"Indicator species" each at nominal 2 ozs. per acre	‡	‡	‡	‡	‡																					

*, †, †† — New Zealand certified mother seed, pedigree and permanent pasture seed respectively.

‡ — "Indicator species." Meadow fescue, cocksfoot, red fescue, smooth-stalked meadow grass, crested dogstail, alsike, trefoil, sainfoin, lucerne, *Lotus*, burnet and chicory.

effect of the group of strains. In subsequent years (1938-1943) the majority of mixtures compared the behaviour of single strains within a species.

The seeds mixtures used have been simple ones, of the type now employed in the establishment of medium-to long-duration leys. The mixtures sown in 1940, 1942 and 1943, from which most of the data have been collected, are set out in Table I. We have advisedly distributed the trials as widely as possible throughout the country in order to get a reasonably complete picture representing a large number of edaphic and climatic variations. The trials have, therefore, been extended into every English county. The wide geographical distribution of the trial centres, and working under the difficulties of war-time conditions, have militated against the collection of much detailed data which would have given added value to the experiments. For example, it has not been possible to collect data relative to herbage production. Fairly complete and comprehensive data on the ground cover contribution of the sown and other species have been accumulated and these will be discussed at some length in this article.

Perennial Ryegrass Strains.

Three series of trials were sown which afforded comparison between certain strains of perennial ryegrass. These were sown in the years 1940, 1942 and 1943, and the seeds mixtures are given in Table I.

In 1940 a perennial ryegrass, timothy, red clover and white clover type of mixture was used and the three strains, commercial, S.23 pasture type and S.24 leafy hay type, were compared together with two mixtures containing varying proportions of commercial and S.23 perennial ryegrass. This series of mixtures was sown at eight centres. The mixtures sown in 1942 and 1943 were very similar in that each year two series were sown, one being a perennial ryegrass and cocksfoot mixture, and the other a perennial ryegrass and timothy mixture. In both years these grasses were sown with Italian ryegrass, red clover and white clover and trefoil. In 1942 alsike was a constituent common to all mixtures, while in the 1943 trials subterranean clover was included in one of the mixtures.

In the 1940 series of perennial ryegrass mixtures small quantities of other species of grasses, clover and herbs were sown in all the five mixtures as "indicator species" which included meadow fescue S.53, cocksfoot S.192, creeping red fescue S.59, smooth-stalked meadow grass, alsike, crested dogstail, trefoil, sainfoin, lucerne, *Lotus major*, burnet and chicory. The seeding rate of each of these indicator species was two ounces per acre.

Data concerning the behaviour of the various perennial ryegrass strains have been obtained from relatively simple mixtures in which perennial ryegrass was sown with cocksfoot or timothy, plus red and white clover.

Ground cover analyses were carried out on the 1940 sown trials in 1943 and 1945, *i.e.*, in the third and fifth harvest years. The percentage contribution of perennial ryegrass as measured by ground cover in these years is given in the following statement :—

	Per cent. ground cover perennial ryegrass		Strain of perennial ryegrass
	Range 1943	Range 1945	
Mixture I*	From 15.5 to 34	14 5 –16.5	Commercial
Mixture II	,, 25 to 52	22 —38	Aberystwyth S.24
Mixture III	,, 47.5 to 62	42 —47	Aberystwyth S.23
Mixture IV	,, 27.5 to 44	21 —41	Commercial and S.23 in ratio of 3 : 1
Mixture V	,, 34.5 to 39.5	—	Commercial and S.23 in ratio of 1 : 1

*see Table I for details of seeds mixtures.

Although there was considerable variation between individual centres in the amount of perennial ryegrass contributing to the swards, at every centre commercial ryegrass was the least plentiful in both the third and fifth years, while without exception the S.23 strain produced the most dominant perennial ryegrass sward. The behaviour of the strain S.24 was intermediate between the above two strains. It is interesting to note that the mixing of strains had a direct influence upon the resultant sward much as would be expected from a knowledge of the individual behaviour of the strains. Thus, even in the third harvest year, the influence of the multi-tillering S.23 had markedly increased the contribution of ryegrass to the sward, even when sown with commercial in a 3 : 1 ratio. These data are borne out again by the figures for the fifth harvest year.

The results of ground cover analysis of swards, as set out in Tables II to V, are averages drawn from a large number of trials which have received normal farm management. The majority have been grazed in each year but a few were cut for hay, either in the first or second year.

TABLE II. showing per cent. ground cover of perennial ryegrass and cocksfoot derived from various strains. 1942 sown mixtures.

Perennial ryegrass strains.	Cocksfoot strains	per cent. ground cover of Perennial ryegrass		per cent. ground cover of Cocksfoot	
		1943	1945	1943	1945
(*i*) Irish (commercial)	U.S.A. (commercial)	32.8	19.6	5.1	5.0
(*ii*) S.24 (leafy hay)	S.37 (leafy hay)	34.2	23.2	7.4	10.8
(*iii*) S.23 (pasture)	S.143 (pasture)	49.6	43.2	6.6	7.7
(*iv*) N.Z. mother seed	N.Z. cert. mother seed	33.2	23.6	5.8	9.7
(*va*) N.Z. pedigree seed	N.Z. ped., C.23	32.6	29.5	4.2	4.0
(*vb*) Mixed strains	Mixed	38.7	26.1	6.7	11.6

TABLE III. showing per cent. ground cover of perennial ryegrass and cocksfoot derived from various strains. 1943 sown mixtures.

Perennial ryegrass strains	Cocksfoot strains	Per cent. ground cover in 1945	
		Perennial ryegrass	Cocksfoot
Irish	U.S.A.	23.6	6.2
S.24	S.143	29.6	12.2
S.23	S.143	46.1	6.2
N.Z. mother seed	N.Z. cert. m.s.	30.6	6.6
N.Z. H.I. (Short rotation)	N.Z. cert., ped., C.23	24.0	3.0

TABLE IV. showing per cent. ground cover of perennial ryegrass and timothy, derived from various strains. 1942 sown mixtures.

Perennial ryegrass strains	Timothy strains	per cent. ground cover of perennial ryegrass		per cent. ground cover of timothy	
		1943	1945	1943	1945
Irish	U.S.A.	33.0	29.1	2.7	7.0
S.24	U.S.A.	38.1	35.2	1.9	6.9
N.Z. mother seed	U.S.A.	44.6	43.6	2.4	4.1
10 lb. Irish + 6 lb. S.23	S.51	38.5	46.5	2.1	5.3
do. do.	S.48	38.6	38.9	7.2	9.2

TABLE V. showing per cent. ground cover of perennial ryegrass and timothy derived from various strains. 1943 sown mixtures.

Perennial ryegrass strains	Timothy strains	Per cent. ground cover in 1945	
		Perennial ryegrass	Timothy
Irish	U.S.A.	26.2	5.1
S.24	S.51	31.5	4.0
S.23	S.48	42.8	7.5
N.Z. cert. mother seed	S.48	30.8	10.1

In the 1942 sown trials the contribution of the various strains was estimated in the first (1943) and third (1945) harvest years, while in the case of the 1943 sown trials, ground cover analysis was made in the second harvest year (1945). Commercial perennial ryegrass (Irish) has contributed less to the ground cover than any of the other strains (Tables II toV). In this respect, there was a high degree of uniformity throughout the trial centres although on occasion there was no significant difference between commercial and either S.24 or New Zealand certified. The behaviour of Irish ryegrass appeared to be more similar to the other strains where the swards had been put up to hay and under conditions of higher-than-average soil fertility and when intensity of grazing was not heavy. When standing hay crops were inspected it was apparent that the quality of the herbage produced by S.24 and N.Z. certified strains was superior to that of the commercial in that the latter carried a lower leaf to stem ratio than the former two strains.

At the majority of centres the Aberystwyth S.24 and the New Zealand certified strains were fairly similar in their contribution (Tables II, III, V), although there is a distinct difference in their behaviour in the swards in the ryegrass-timothy series sown in 1942 (Table IV), in which the New Zealand strain contributed better than S 24 in both the first and the third years. The probable explanation for this divergence in the behaviour of the two strains may be found in the fact that the sites chosen for the perennial ryegrass and timothy mixture were generally on soils retentive of moisture (heavy loam or clay) and at a higher fertility level than those for the ryegrass/cocksfoot series of the same year. This conclusion is supported by field observations and by the fact that all the perennial ryegrass strains have performed relatively better in the ryegrass/timothy series. It would thus appear that, while on soils of average fertility, there is little difference in the agronomic behaviour of S.24 and New Zealand certified, under conditions of high fertility the latter may dominate the sward.

The higher contribution made throughout by the pasture strain, S.23, compared with other strains, has been a uniform feature of all the trials (Tables II, III & V). At no centre has its contribution to the ground cover been exceeded by any other strain and with increasing age of the ley, the difference tends to be still more in favour of S.23.

In the ryegrass and cocksfoot trials, sown in 1942, New Zealand pedigree perennial ryegrass was used at a limited number of centres but in no case did this differ markedly from the mother seed strain. The New Zealand pedigree seed is one generation nearer to stock seed but so far in our trials, no agronomic differences have been revealed between the two grades. No distinction, therefore, is drawn between them in the course of the present article.

The differences between the contribution of the commercial, S.24, New Zealand certified and S.23 strains tend to widen at least up to the third year. The results from our earlier trials suggest that there is a further widening in later years, particularly in the case of the pasture strain, S.23. This is a manifestation of the greater persistency of the pasture

strain, S.23, while the least persistent has been the commercial strain with S.24 and New Zealand certified, together assuming an intermediate position.

The habit of growth of the perennial ryegrass strains remained remarkably uniform, irrespective of variations in soil fertility or of local climatic conditions. In all situations, S.23 gave rise to the most dense sward, commercial ryegrass conversely the least dense, with the other strains intermediate. The S.23 strain was from two to three weeks later in commencing active growth in the spring but it continued growth much later into the autumn than the other ryegrasses. There was no marked difference between the hay strains (S.24, New Zealand certified, or commercial as regards earliness of spring growth, all being equally early. The higher leaf to stem ratio of S.23 was most marked at time of normal flowering in May and June, indeed, under satisfactory rotational grazing, few flowering stems were produced at any time on the S.23 plots.

The relative palatability of the strains showed marked seasonal variations. During the early spring the pasture strain S.23 was distinctly less palatable than the other strains; the latter, at this season, exhibited no constant observable difference in respect of palatability. With the production of flowering heads, the relative order of palatability changed so that at mid-season the S.23 became the most palatable. Within a normally palatable species as ryegrass, therefore, palatability shows a seasonal fluctuation and is directly associated with succulence and rapidity of leaf growth. Leaf is normally more palatable than stem, while the relative palatablity of leaf *qua* leaf is apparently a function of rapidity of leaf production and growth. It is interesting to note that although the S.24 and New Zealand certified strains produce flowering heads almost to the same extent as the commercial lots, the former maintained their production of leaf to a greater extent at this period of growth than did the commercial perennial ryegrass.

A strain of ryegrass known as " short rotation (H.I.) ryegrass " provided by the New Zealand Department of Agriculture, was tested at a few centres in 1943. This strain is a hybrid derivative of perennial × Italian ryegrass. The data (Table III) show that the strain has persisted, up to the end of the second year, as well as the Irish perennial ryegrass (Italian ryegrass had virtually disappeared by the end of the first year). This strain (H.I.) has a longer season of growth than any perennial ryegrass strain included in these tests; the production of inflorescences is also less than in perennial ryegrass strains, with the exception of S.23. At all seasons H.I. appears to be outstandingly palatable, comparable in this respect with Italian ryegrass. Recovery after grazing is very rapid, particularly under fertile soil conditions.

The influence upon the resultant sward of sowing mixed strains was quite apparent throughout the trials and corroborated the observation made in earlier trials.

Cocksfoot Strains.

Cocksfoot is generally used in conjunction with other grasses in seeds mixtures and in the majority of the trials now reported upon, cocksfoot has been used in mixtures as a subsidiary species to ryegrass.

In 1937 a perennial ryegrass and cocksfoot with clover type of mixture was used, consisting of Italian ryegrass 4 lb., perennial ryegrass 16 lb., cocksfoot 8 lb., rough stalked meadow grass 1 lb., red clover $3\frac{1}{2}$ lb., wild white clover 1 lb. There were ten centres at which this type of mixture was used. At each centre two mixtures were sown, (*a*) consisting wholly of commercial strains, (*b*) consisting of three parts S.23 and one part commercial ryegrass with pedigree strains of cocksfoot. Five of these trials were still in existence in

1941/42; two comparing S.37 and three comparing S.146* with the Danish cocksfoot. The percentage contributions of these cocksfoot strains are presented in Table VI and the percentage contributions of the cocksfoot strains sown in the 1942 and 1943 series appear in Tables II and III. In each instance, the accompanying strain of perennial ryegrass is given together with the latter's contribution to the sward.

TABLE VI showing the per cent. ground cover contribution of cocksfoot and perennial ryegrass strains used in mixtures sown in 1937.

Perennial ryegrass strain.	Cocksfoot strain	per cent. ground cover in 1941-42	
		Perennial ryegrass	Cocksfoot
(*i*) Commercial only	Danish	7	15.5
(*ii*) S.23 and Commercial (ratio 3 : 1)	S.146	11	30
(*i*) Commercial only	Danish	15	15
(*ii*) S.23 and commercial (ratio 3 : 1)	S.37	17.5	26.5

As a rule the hay strains and pasture strains were sown in separate mixtures and it is necessary to interpret the contribution of any particular strain of, say cocksfoot, in relation to that of the accompanying strain of perennial ryegrass. The Danish cocksfoot in the 1937 trials and the U.S.A. cocksfoot in the 1941/42 trials, although sown with the least persistent (commercial) ryegrass strains, both contributed less to the swards than the bred strains, although the latter were in association with the more aggressive strains of ryegrass. The competitive influence which perennial ryegrass exerts upon cocksfoot is well marked in the 1943 trial (Table III). Thus, in the second year (1945) S.143 cocksfoot contributes 12.2 per cent. to the ground cover when sown with S.24 ryegrass, while it only contributed 6.2 per cent. when sown with the more aggressive S.23 ryegrass.

The pasture strain, S.143, was considerably more persistent than any of the other strains, giving rise to more abundantly tillered plants; these characters were very evident under conditions of lower fertility and relatively hard grazing. Under conditions of high fertility and when the grazing was by cattle, S.37 and New Zealand certified mother seed proved as persistent as S.143 up to the third or fourth year after sowing. U.S.A. cocksfoot was earlier in commencing growth than other strains but rapidly produced flowering heads. Aftermath growth was poorer in the case of U.S.A. cocksfoot than any of the other strains. The S.37 and New Zealand certified mother seed represent types intermediate between the two extremes of U.S.A. and S.143 cocksfoot. They were slightly later than the U.S.A. in commencing spring growth but they recovered well in the aftermath and after grazing, while also remaining green when U.S.A. strains suffered from frost "burn." The New Zealand pedigree strain, C.23 cocksfoot, was sown at a limited number of centres but the figures are not directly comparable with those of the other strains. From observation, this strain produces plants which are slightly denser and better-tillered than those from New Zealand mother seed although not so multi-tillered as the Aberystwyth strains S.143 or S.190.

Table VII presents the mean ground cover analyses at eight centres in 1943 (third year) for the ryegrass-cocksfoot swards sown in the 1940 series.

*S.146 is of the same general (mop) type as S.143.

TABLE VII. showing the per cent. ground cover in the third harvest year: cocksfoot strain series. Sown 1940 at eight centres. Analysis 1943.

	Mixtures					lb. per acre	Strain.
	I	II	III	IV	V		
Italian ryegrass	--	—	-	- -	—	8	Irish all mixture
Perennial ryegrass	25.9	20.3	18.5	17.4	18.1	10	Irish all mixture
Cocksfoot	5.6	9.4	22.3	23.3	15.0	16	I Danish, II S.191, III S.192, IV S.190, V. Mixed Commercial
Rough-stalked meadow grass	10.6	10.1	8.2	8.1	9.6	1	
Unsown grasses	14.8	17.0	10.0	12.2	15.4		
Red clover	2.6	1.4	0.9	1.1	2.3	4	I Mont., II-V S.123
White clover	21.6	26.9	25.5	24.0	25.5	2	I S.100, II-V Kentish
Miscellaneous weeds	8.0	5.5	5.5	6.5	6.3		
Bare Ground	10.9	9.4	9.1	7.4	7.8		
	100	100	100	100	100	39 lb.	

In the earlier trials, Danish cocksfoot was used as the standard but later, when Danish seed was not available, U.S.A. cocksfoot was used as the standard commercial strain. Experience has shown that the U.S.A. and Danish type are closely comparable in their field behaviour, both being early, few-tillered and relatively short-lived. Of all strains under observation in these trials, Danish and U.S.A. cocksfoot made the smallest contribution by the third year. In all seasons they were less abundant than the pasture strains but in the first year S.191 was less plentiful than the Danish; the S.191 leafy type hay had the appearance of being poor in initial establishing power.

The three bred strains of cocksfoot used in the 1940 sowings (Table VII) have not been placed on the market. S.191 is a leafy hay type which had considerable promise but unfortunately, produced seed of low viability. Largely for this reason it has been discarded. S.192 was of the "mop" type, resembling S.143 and showing no advantage over the latter. The strain, S.190, is a fairly fine-leaved close-tillered type, representing forms found in the old pastures of Leicestershire. S.190 shows considerable promise as a strain for long duration leys and we feel there is sufficient evidence in its favour to warrant going ahead with commercial multiplication.

The eight centres at which the 1940 cocksfoot was sown ranged from Durham to Cornwall, and varied in altitude from about 200 feet to 1,300 feet above sea level: it is interesting to note that both pasture strains did equally well at all situations and there was no indication that any particular environment favoured one pasture strain more than the other. Earliness of spring growth was in reverse order of the persistency of the strains. Danish cocksfoot was the least persistent of the strains under test: S.191 (hay type) proved rather more persistent though initially less well established. The two pasture strains, S.192 and S.190, were markedly more persistent and obviously fall into a distinct group of their own in sharp contrast to the hay strains.

Timothy Strains.

The mixtures used for comparison of timothy strains have, in all cases, included perennial ryegrass, timothy, red and white clover also with rough stalked meadow grass in 1937 and

1940. In 1937, 1942 and 1943, the timothy strains varied with the perennial ryegrass strain and the contribution to the sward of both species is given in Tables IV, V and VIII. In 1940, direct comparison of the strains was obtained from a few centres and the content of timothy at individual centres of this series in the different years, is presented in Table IX.

TABLE VIII showing the per cent. ground cover contribution of timothy and perennial ryegrass strains used in mixtures sown in 1937.

Perennial ryegrass strain	Timothy strain	per cent. ground cover in 1941-1942	
		Perennial ryegrass	Timothy
(*i*) Commercial	Commercial	30	11
(*ii*) S.23 and commercial (ratio 3 : 1)	S.48	28	23½

TABLE IX. showing the per cent. ground cover contribution of various timothy strains for trials at three centres, sown in 1940.

	Centre No. 3		Centre No. 4			Centre No. 7	
	1941	1942	1941	1942	1943	1942	1943
Commercial	8½	4	6	10	11½	10	7
S.51 (leafy hay type)	8½	13	3	9	13	12	6½
S.48 (pasture-hay type)	12	27	14½	19½	25½	17	10½
S.50 (pasture type)	13½	11	15½	31½	40½	16½	20½
Mixture of four strains	9½	4½	7½	10	17	17	11

As regards contribution to ground cover, there has been little to choose between U.S.A. and S.51. As hay, the latter was always more abundant than the former, while, in addition, S.51 produced a more leafy hay than the commercial strain. Under pasture conditions, S. 48 (pasture-hay) always contributed considerably more to the sward than either U.S.A. or S.51 even in the first year after sowing, while by the third year, the difference tended to widen. The pasture type, S.50, proved to be the most persistent and spreading of the timothy strains under observation but in productivity, it was decidedly poorer than the other strains.

The difference in earliness of spring growth was not marked as between the commercial, S. 51 and S.48 strains, whereas S.50 was distinctly later in spring but provided better growth in early autumn.

It is of interest to note that the S.48 and S.50 strains in particular were capable of producing hard-wearing swards which could carry cattle during late autumn and early winter without undue damage by poaching. This is true where timothy has been used as the dominant grass in the mixture and where the competitive ryegrass has been omitted or sown in very small amount.

White Clover Strains.

The strains which have been under observation in these trials, include Kentish or certified wild white clover, S.100, New Zealand uncertified, New Zealand certified mother seed and New Zealand pedigree seed.

The actual quantities of white clover present, as expressed by ground cover, may bear little relation to the strain sown, since the proportion of white clover will often be a reflection of the persistency and aggressiveness of the gramineous components of the sward. From observation one can, however, state that the large-leaved strains of white clover, as re-

presented by S.100 and the New Zealand certified strains, persisted in adequate quantity for three or four years under conditions of average fertility. Under the poorest conditions, on thin soils and hill lands, the large-leaved types tended to disappear in the second or third year but under high fertility conditions these strains showed little signs of diminishing, even in the fourth or fifth years. Where large-leaved types were sown, smaller-leaved types usually made an unsown appearance in the sward and these increased in quantity with the age of the ley. These smaller-leaved types presumably represented indigenous forms, the seed of which would be present in the soil, particularly where the ley had followed immediately after old pasture. The dispersal of seed through animal agencies, no doubt, also plays an important part in the appearance and spread of these indigenous types.

Red Clover Strains.

In the various seasons we have tested the behaviour of the several strains and types of red clover, including English broad red and various contrasting types of late flowering red clover. As would be expected, broad red clover has failed to persist in any quantity after the first harvest year; a few weakly plants are to be found in the second year, while none remain to contribute to the swards in the third and later harvest years. American Mammoth red clover is of the late flowering type but under the conditions of the trials, it also failed to make telling contribution to the swards after the first year, being therefore little more persistent than English broad red clover. Cotswold late-flowering red, made good contribution in the second harvest year at most centres but made only minor growth in the third year. Montgomery red clover (including New Zealand grown seed) and Aberystwyth S.123 made an important contribution in the first and second years and even in the third and sometimes in the fourth year there were individual plants which made robust growth. The data shown on Table VII are fairly characteristic of the behaviour of these (Montgomery type) strains in the third harvest year, making an average contribution of about two per cent. to the ground cover. In these trials, S.123 has not persisted appreciably better than Montgomery red, although, on the whole, the proportion of dense high tillering plants is greater in S.123.

Subterranean Clover.

Subterranean clover was tested in the 1943 series. One pound per acre of a mid-season strain of subterranean clover was added to mixture 1 at all trial centres established in 1943. Its behaviour upon light sandy soils in the low rainfall areas of England is being further investigated in another series of trials. The germination of the subterranean clover and its early establishment was everywhere good but the quick establishment of a close, and often dense sward as usually achieved in this country, proved detrimental to the full development of this clover. Nevertheless, it has shown some qualities of persistence up to the autumn of 1945 and at this date seedlings were establishing at the majority of centres. Under suitable climatic conditions, these seedlings would persist to produce plants in the following year. In 1945, the second year after sowing, subterranean clover plants were observed in the spring and early summer, and as seedlings in the autumn, at nineteen of the twenty-five trials at which critical ground cover analysis was carried out. However, it was at only one centre that subterranean clover contributed more than white clover to the sward. At the great majority of centres, the relative abundance of the two species was distinctly in favour of white clover. At the single centre, where subterranean clover was the more abundant, it contributed five per cent. of the ground cover, white clover contributing three per cent. The soil was a sandy loam. With this single exception, the inclusion of subterranean clover in mixtures upon soils ranging from light loams to heavy clays has not been justified. Where

white clover can be successfully established and maintained as is the case over the greater part of Britain, it is likely to be a far more valuable herbage plant than subterranean clover for sowing in orthodox mixtures designed for long duration leys.

GENERAL DISCUSSION.

The wide distribution of the trials laid down from 1940 to 1943, has afforded an opportunity to observe, under normal farm conditions in England, the relative behaviour of a large number of species and strains included in modern seeds mixtures for temporary and permanent pastures.

The main emphasis throughout is on the comparative behaviour of the different strains within the chief grasses and clovers. In general, the trends of evidence are similar throughout the trials; in most cases the extreme pasture types have shown to advantage in regard to persistency, leaf production, tillering and therefore tend to dominate the swards in the later years of the life of the ley. The more lax (hay) strains have, on the other hand, made earlier growth in the spring, some of the bred hay types showing good persistency and sward-forming ability, particularly on land in good heart. Some of these strains, such as S.24 ryegrass and S.37 cocksfoot, make good pasture types on fertile soils.

It has also been possible to judge whether particular strains respond differently under contrasting climatic, soil and fertility conditions. Data have been collected relating to the influence of grazing management as experienced under commercial farming conditions. Broadly, all the strains of grasses and clovers have behaved in much the same relative manner when compared one to another in their gross characters of morphology, persistency and palatability under the varying conditions. Probably the most constant relative behaviour has been observed in that of habit of growth, such as, in the case of the grasses, their tillering powers, density of growth and leafiness. The persistency of a particular strain has varied quite appreciably according to fertility conditions and grazing management but the trend of the effects of these conditions has been in the same direction when the behaviour of different strains was compared. Marked differences between strains occur in their relative persistency and the superior persistency of the bred pasture types is most marked under conditions of average to low soil fertility, particularly where there is adequate or high rainfall. Under these conditions, the superior persistency of the bred pasture strains appears early in the life of the ley, while with increasing fertility, the difference between the non-bred together with the bred hay strains and the pasture strains does not appear so early in the life of the ley. On really fertile soils the commercial grasses persist fairly well: this is perhaps more true of ryegrass than of either cocksfoot or timothy when sown in mixtures with ryegrass.

At any given level of soil fertility the type of grazing management has an overriding influence upon persistency. Continuous hard grazing always has a detrimental effect upon the longevity of the better grasses. This effect is inversely proportional to tillering in the particular strain. The pasture strains of perennial ryegrass, cocksfoot and timothy are all better tillereed than the leafy hay strains, the commercial strains being still less well tillered. Under conditions of hard grazing the commercial strains die out more rapidly than the pasture strains over the whole range of fertility conditions.

With irregular grazing or too lenient grazing, the pasture and pedigree hay types fare no better than the commercial; all tend to be suppressed by unsown weed grasses such as *Agrostis*, Yorkshire fog and soft brome. Under these latter conditions, however, the large leaved types of white clover, such as S.100 and New Zealand certified strains, were less affected by undergrazing than the more prostrate wild white clover.

TABLE X. To show the influence of environmental factors upon strain behaviour. Percentage ground covers at selected centres in 1945 (fourth harvest year). Mixtures sown 1941 (except IB).

Centre	1A		2A		3A		4A		IB	
County	Norfolk		Leicester		Bucks.		Staffs.		Hereford.	
Mixtures	ped. III	comm. IV	ped. III	comm. IV	ped. III	comm. IV	ped. III	comm. IV	ped. III	comm. I
Perennial ryegrass	32.5	11.0	34.5	28.5	23.0	21.0	27.0	13.0	43.5	13.5
Cocksfoot	1.5	4.0	6.5	4.0	15.0	5.5	31.5	22.5	2.5	1.5
Timothy	6.0	1.5	17.0	2.0	2.5	Trace	4.5	0.5	—	–
Other grasses	22.0	31 0	7.5	15.0	32.0	41.0	11.0	15.5	16.5	29.5
Red clover	–	—	-	--	—	1 5	0.5	Trace	1.0	-
White clover	21.5	25.5	20.5	33.0	16.5	17.5	2.0	1.5	8.5	5.0
Weeds	2.5	6.5	1.5	1 5	6.0	11 0	12.5	24 5	12.0	12.5
Bare ground	14.0	20.5	12.5	16 0	5.0	2.5	11.0	22.5	16.0	38.0
	100	100	100	100	100	100	100	100	100	100

1A : Close rotational grazing, good fertility, adequate soil moisture.
2A : Rotational grazing, good fertility, low soil moisture.
3A : Lenient grazing, good fertility, low soil moisture.
4B : Rotational grazing, low fertility, heavy manuring, high rainfall.
1B : Hard sheep grazing, low fertility, high rainfall.

To illustrate the influence of grazing management and soil fertility upon the growth and persistency of contrasting strains the alnalyses made in 1945 are of interest. These data from comparative mixtures at a number of individual centres are given in Table X. The 'A' series of centres are from the 1941 sown trials; pedigree mixture III contains a proportion of pedigree grasses and clovers, while mixture IV is composed entirely of commercial strains. At centre IA the management was close rotational grazing and fertility conditions were good. The trial was situated on the coastal marshes of Norfolk and the conditions of the soil moisture were good. In this instance the persistency of the pedigree ryegrass was markedly greater than that of Irish. The behaviour of the timothy strains was similar but that of the cocksfoot was reversed.

Centre 2A is on fertile heavy loam in Leicestershire, under conditions of good rotational grazing. Although the persistency of the Irish perennial ryegrass is not as good as where a proportion of pedigree was used, the difference is not great. Wide differences are, however, obtained in the behaviour of the timothy strains. Differences between the perennial ryegrass complement of the swards were small at centre 3A (Buckingham) where grazing was lenient. The standard of soil fertility here was good (a heavy loam) in medium to low rainfall. The grazing management, however, has resulted in a high proportion of cocksfoot where pedigree strains have been used (Mixture III). Centre 4A is an example of centres established on poor acid millstone grit at an elevation of 900 feet but supported by adequate liming and liberal phosphate manuring at the time of sowing and again in the autumn of the first and second harvest years. At this centre, the pedigree strains of all the sown grasses have proved superior to the commercial strains. The seeds mixtures sown at centre IB was that of the ryegrass -cocksfoot series sown in 1942 (Table I). Fertility conditions here were poor, initial phosphatic manuring was inadequate, while the annual rainfall is about 45 inches and the elevation around 600 feet. Grazing was, at all seasons, very hard; the disparity in the proportion of perennial ryegrass in Mixture III and I, S.23 and Irish respectively, is very wide, while from the low proportion of cocksfoot in both swards, it is obvious that the intensity of grazing was too severe for the survival of either strain.

NOTES ON INDIVIDUAL STRAINS.

The following are brief descriptions of the morphological characters and behaviour in the sward of the various strains of grasses and clovers used in the series of trials which are reported above.

Ryegrass Strains.

Perennial ryegrass—Irish. This strain commences growth at the same time as the pedigree S.24 and New Zealand certified Individual plants are few tillered and not persistent. Under the majority of conditions, swards derived from Irish perennial ryegrass are characteristically open compared with swards derived from the more leafy strains. Compared with the pasture type, S.23 and pasture-hay type, S.101, Irish ryegrass produces inflorescences in great abundance in late spring and early summer.

Perennial ryegrass—New Zealand certified seed. The New Zealand certified perennial ryegrass, now exported to this country, is derived chiefly from bred strains at different stages of multiplication. In these trials there was no evidence to suggest that pedigree seed differed materially from mother seed in its behaviour in the field The type is considerably more persistent and better tillered than Irish perennial ryegrass and is comparable to Aberystwyth S.24. As hay, New Zealand certified ryegrass gives a higher proportion of leaf to stem compared with Irish ryegrass. The trials tended to show that New Zealand certified ryegrass requires a high level of soil fertility for full development under which conditions it can contribute a higher proportion of ryegrass to the sward than any other strain with the exception of S.23. Although the New Zealand strains produce an abundance of inflorescences, leaf production is maintained better during this phase than is the case in Irish perennial ryegrass. The New Zealand strains were highly resistant to yellow rust and this feature was largely true throughout the trials.

Aberystwyth S.24 leafy hay type perennial ryegrass. Spring growth commences in this strain at approximately the same time as in Irish ryegrass but owing to its greater tillering capacity, the total quantity of leafage produced is greater than in the case of the latter. Under grazing conditions, stem production is less than in Irish and, as is the case with New Zealand perennial ryegrass, the production of leafage during summer and autumn is also proportionally better than in Irish perennial ryegrass.

Aberystwyth S.23 pasture type perennial ryegrass. The main feature which distinguishes this strain is its high tillering capacity, which renders it able to produce a dense persistent sward when properly managed. It is from two to three weeks later than the hay strains in commencing active spring growth and is similarly later in running to stem. Under suitable conditions the strain produces few inflorescences but an abundance of leafy herbage. It continues growth later into the autumn than other strains of perennial ryegrass we have had in the trials.

Aberystwyth S.101 perennial ryegrass. This strain has not been sufficiently widely tested in the above trials. In some respects, it is intermediate between the S.23 and S.24 but in its general behaviour as a pasture or hay plant when used in mixtures, it is closely similar to S.23.

Italian ryegrass strains. Three types were tested in trial mixtures, namely, the Irish type, the New Zealand pedigree and New Zealand mother seed. No difference was observed between the last two strains but both were more persistent than Irish, individual plants being considerably better tillered and the ratio of leaf to stem higher.

Short rotation ryegrass. H. I. (New Zealand). This strain is derived from the hybridisation of Italian and perennial ryegrass. Individual plants vary considerably in morphology and exhibit characters approaching both parents. In the trials, the strain has persisted up to the end of the second year about as well as Irish perennial ryegrass. Swards derived

from H.I. showed that it has a longer season of growth than perennial ryegrass. It is leafy and not prone to run to stem and seed, while it is also highly palatable. Recovery after grazing is rapid, particularly under fertile conditions.

Cocksfoot Strains.

Danish and U.S.A. The former strain was used only in the 1937 and 1940 sowings, while subsequently U.S.A. cocksfoot was used. Both strains are poorly tillered, producing lax, erect plants with broad tillers and a high proportion of fertile shoots. Flowering culms carry a minimum of leafage. Hay produced from these strains tends, therefore, to be coarse and stemmy and of low nutritive value. Only under a system of lenient grazing are these strains persistent.

New Zealand certified mother seed. This strain commences growth later than Danish or U.S.A. cocksfoot but it more persistent and leafier than the commercial types. It closely approaches S.37 cocksfoot and like the latter is more suited to the better fertility conditions and cattle grazing, or for the production of leafy hay.

New Zealand certified S.23 pedigree. This strain has not been subject to extensive trials. In type it is slightly better tillered than the mother seed cocksfoot although not so well tillered as the pasture type S.143. In general character it belongs to the group of leafy hay types such as S.37 or New Zealand certified mother seed.

Aberystwyth S.37 leafy hay type. This strain commences spring growth later but it is very much better tillered than commercial strains. The production of inflorescences is not so abundant and when cut for hay, the ratio of leaf to stem is higher and the stems carry far more leafage. Originally intended as a hay type, it has nevertheless proved a very satisfactory grazing type for average lowland conditions, particularly where the bulk of the grazing is done with cattle. S.37 is intermediate between the lax hay types and the pasture type, S.143. Under hard grazing, and on poor thin soils, it is not as persistent as S.143 but on fertile soils and under cattle grazing conditions, S.37 is remarkably persistent and productive.

Aberystwyth S.143 pasture type. This is slightly later in commencing growth than S.37 and is more densely tillered. Under lenient grazing and fertile conditions it can be very aggressive but as with S.37, grazing management is comparatively easy in that its high proportion of leaf is attractive to stock. The high tillerage abilities of this strain makes it more suitable than S.37 for conditions of low fertility and hard grazing.

[The strains S.192 and S.146, used in some of our trials, exhibit agronomic characters similar to S.143 while the general behaviour of the Leicester pasture type, S.190, has again been somewhat similar. All four strains fall into one closely allied group].

Timothy Strains.

U.S.A. Timothy. The characters of this type which distinguish this strain from the strains to be described below, are its stemminess, poor tillering and lack of persistency, particularly under grazing conditions.

Aberystwyth S.51 hay type. This strain is only slightly better tillered than the above and under grazing conditions, behaves very similarly. Under hay conditions the strain differences are more marked, the ratio of leaf to stem being higher and the stems carry long leaves well up the culm; root leaves are also longer. S.51 is, therefore, definitely a type suitable for the production of short term hay leys.

Aberystwyth S.48 pasture-hay type. This type is a marked departure from the foregoing strains. Plants of this strain are densely tillered and the strain is capable of increasing its relative contribution to the sward as the ley becomes older. Under average conditions of

fertility and under a proper system of rotational grazing, S.48 makes an excellent pasture plant. As hay it exhibits characters similar to S.51.

Aberystwyth S. 50. This is an extreme pasture type, fine leaved and dense at the crown and it will spread vegetatively by means of trailing stems produced in the late autumn. It is a most persistent strain under hard grazing conditions and may prove an invaluable pasture plant.

Red Clover Strains.

While the general behaviour of both broad and late flowering red clover is well recognised, mention must, however, be made of the fact that the lots of English late flowering red clover used in the 1941 and 1942 trials differed little from typical broad red in agronomic characters. In neither case was the seed certified and this raises an important point in relation to strains in herbage plants as well as the need for a sound certification scheme whereby both trade and farmer are assured of the genuineness of the stocks they handle.

Late-flowering red clover strains. (*Single cut cowgrass*). Of the certified late flowering strains, Cotswold late was the first to commence active growth in the spring. Observation to the end of the second harvest year showed that it persisted well during this period. The New Zealand certified Montgomery strain commenced spring growth a little later than Cotswold late, was very uniform in type and persisted well into the second harvest year, with a good proportion surviving into the third harvest year. It proved to be better tillered than Cotswold though not so well tillered as Aberystwyth S.123 late-flowering red clover. Spring growth in S.123 is late relative to the other strains. Under grazing conditions S. 123 produces dense cushion-like plants. On the balance, S.123 has been the most persistent strain used in the trials though the difference between it and Montgomery red was not great.

White Clover Strains.

The value of genuine wild white clover is well known. When properly manured and managed it was the most persistent strain under trial.

New Zealand uncertified white clover seed was used in 1942 and 1943 and the two samples differed considerably. That used in 1942 proved to be a small leaved type which, by the third harvest year, showed a definite tendency to die out. The lot of uncertified seed, used in the following year, was undistinguishable in the sward from the certified strains. This experience again illustrates the value of a proper and sound scheme of certification.

Aberystwyth S.100 white clover. This strain produced large leaved plants, which under average fertility, persisted for the duration of the trials (four years). Under conditions of poorer-than-average fertility its persistency was reduced and it was often replaced in the sward by smaller leaved indigenous types. S.100 is more productive generally than wild white clover. It commences growth earlier than wild white clover and continues growing later into the autumn.

New Zealand certified pedigree and mother seed white clover. No differences in the behaviour of these strains were noted in these trials. Plants of these strains were, on the whole, slightly larger leaved than S.100 under high fertility conditions and spring growth commenced earlier where climatic conditions permitted. As far as could be determined, their persistency is somewhat similar to that of S.100.

THE INFLUENCE OF IMPROVED HERBAGE STRAINS UPON SEEDS MIXTURES AND SWARD ESTABLISHMENT.

The term " commercial strains " is used to describe those strains which were not certified as conforming to a particular type. The term is not altogether satisfactory since the bred, or pedigree, strains are now in commercial use. The " commercial " strains

are normally open, lax and produce seed freely. This is associated with poor persistency, especially when grazed hard and on soils of less than average fertility.

The plant breeder has selected a range of types which have definite application in pasture establishment and production. Factors which have received attention include seasonal productivity, persistency and nutritive value; the latter, in the case of herbage plants, is controlled to a marked degree by the ratio of leaf to stem, since the leaf is higher in nutritive value than the stem. The advent of the new leafy strains is bound to have an important influence upon seeds mixture prescriptions for long duration leys.

The trend towards simplification of mixture has been apparent since the days when Gilchrist first drew attention to the value of strain in cocksfoot and clovers. Compared with earlier seeds mixtures, that recommended by Gilchrist, later known as the Cockle Park mixture, constituted a marked reduction in complexity. The present day leafy pasture types add further emphasis to all this.

The data, as a whole, are in support of the adequacy of fairly simple mixtures. In the 1940 sown trials, upwards of a dozen "indicator" species were added to the mixtures but in no case did the inclusion of these materially change the character of the swards produced. There may be some force in the argument that the grazing animal should not be confined to a restricted diet of grass and clover; there may be added force in the argument that the herbs are of special value in nutrition. The study of the botanical side, however, offers little to suggest that the herbs and other plants will become established in telling amounts when sown as part of an otherwise orthodox type of mixture in which the predominant species is ryegrass. If a more mixed diet, therefore, is necessary, the agronomic evidence would indicate that the means to achieve this desired end is to sow the herbs and "mixed grasses" in specially designed mixtures from which ryegrass and perhaps cocksfoot would be excluded.

In our trials, critical examination of the swards derived from mixtures compounded on lines similar to Gilchrist's mixtures, indicated that further simplification and reduction in the number of species employed could be effected without materially altering sward composition. When pasture types of perennial ryegrass or cocksfoot are used as dominants they may prove highly competitive and to the detriment of other sward components. Thus in the 1943 series, where S.143 cocksfoot was sown with S.24 and S.23 respectively in separate mixtures, the contribution of S.143 cocksfoot to the sward, when included with the pasture strain, was no more than half of that with the leafy hay strain. The competitive character of the pasture strains in the later years of a ley results from their capacity to tiller. In this way they show marked ability to prevent sward deterioration through the ingress of weeds and this has been a marked feature in all our trials. During the early period of establishment and up to the end of the first harvest year, the pasture strains can be suppressive to the point of inhibiting the adequate development of white clover. This can be overcome under practical conditions either by using a mixture of strains or by using ultra-simple mixtures and low seed rates of the pasture strains, particularly S.23 perennial ryegrass. When using low seed rates of the above for sward establishment, a high seed rate of white clover, perferably of the large leaved type, is used.

A low seed rate of a high tillering pasture strain will produce as dense and stable a sward as a higher seed rate of a low tillering strain. In many ways it may be a waste of seed to sow the pasture strains at the same rate per acre as has been customary with the low tillering commercial strains. There are, therefore, two alternatives in the economic use of the expensive pasture strains, firstly, the use of low but nevertheless adequate seed rates and secondly, sowing only a proportion of the persistent pasture strains with some of the commercial or other hay types. The former method results in the immediate production of a balanced sward which can be maintained at a given balance by designed grazing manage-

ment. The change in character with increasing age of the sward is likely, thus, to be at a minimum. Where strains are mixed, however, the lax and short-lived hay types are bound to influence the character of the sward in the early years. The balance of species will then show a gradual change as the shorter-lived types disappear and the persistent pasture types gradually become dominant. Long leys of high quality can be produced by each method so that we have the two alternatives from which to choose.

SUMMARY.

(1) The paper summarizes briefly the results of seeds mixture trials, sown 1937 to 1943, throughout the English counties. The behaviour of contrasting species and strains used in these trials is reported upom.

(2) As measured by area covered, the high tillering pasture and other leafy strains are more persistent and distinctly superior in sward-forming ability than the normal strains of commerce.

(3) Certain aspects of persistency in relation to soil fertility and grazing management are noted.

(4) Observations are made on the competitive influence exerted by one species on another when sown in mixtures. Different strains within the species exhibit marked contrasts in their ability to compete with other elements in the sward.

WILLIAM DAVIES.
T. E. WILLIAMS

GRASSLAND IMPROVEMENT STATION,
STRATFORD-ON-AVON.

Report of the Council to the Annual General Meeting of Governors and Members of the Society

1. This is the first report to be presented by the Council since December, 1939. In each of the years since, a report has been made to governors and members by the Executive Committee to whom the conduct of the Society's affairs was delegated on the outbreak of war. The last of these reports, covering the twelve months to February 1946, with the Accounts and Balance-sheet for 1945, appeared in Volume 106 of the Society's *Journal* circulated at the end of March, 1946. Many of the subjects mentioned briefly herein having already been dealt with in the *Quarterly Review*, it is not onsidered necessary to make detailed reference to them again.

Membership.

2. Since the Executive Committee's last report the following changes in membership have occurred :—50 Governors (including 8 transferred from the list of members under Bye-law 9), 1 honorary life governor and 677 new members have joined ; 2 members have been re-elected under Bye-law 14 ; the deaths of 5 life governors, 10 governors, 39 life members and 117 members have been reported : 4 life members and 3 members have been struck off owing to absence of addresses and 5 members struck off for arrears of subscription. One governor and 33 annual members have resigned and one member removed under Bye-law 109.

3. For the increase in the membership in recent months the Society is indebted in a large measure to the President, Viscount Bledisloe, and to Mr. John Bourne, the elected representative on the Council of Gloucestershire. Between them they have been responsible for introducing 370 new members. Other members have also taken active steps to assist the new campaign for increased membership ; references to the subject in the Society's *Quarterly* appear to be having a most stimulating effect. The Council cannot regard a total of some 7,824 members as nearly adequate and are most anxious to strengthen the position. Steps to this end are being taken and members generally will be kept informed of progress.

4. It is with great regret that the Council has to record the deaths of Mr. William Everall, of Shrewsbury, one of the Society's Vice-Presidents ; of Mr. Leslie K. Osmond, the representative of Lincolnshire, and of Captain H. A. Christy, who represented South Wales.

5. Amongst other governors and members whose passing the Society has to deplore are the Marquess of Bath, K.G., P.C., Viscount Portman, Viscount Southwood, Lord Bagot, Lord Colwyn, Lord Cope, K.C., Lord Crawshaw, Lord Howard de Walden, Lord Hylton, Lord Keynes, C.B., Lord Lilford, Lord Magheramorne, the Right Hon. Lord Richard F. Cavendish, C.B., C.M.G., the Right Hon. Sir A. Griffith Boscawen, the Hon. Mrs. Smyth, Sir Edward Cave, Bt., Sir Richard A. Cooper, Bt., Sir W. H. Feilden, Bt., Sir Thomas Gooch, Bt., Sir Graham P. Heywood, Bt., C.B., D.S.O., Sir Thomas Lawson Tancred, Bt., Sir Francis Samuelson, Bt., Lieut-Col. Sir Murrough J. Wilson, K.B.E., Sir R. F. Lancaster, Sir Albert Ball, Sir Herbert Brown, K.B.E., Sir Jesse W. Hind, Sir Crosland Graham, Sir Charles Marston, F.S.A., Sir S. Hanson Rowbotham, Lieut.-Col. E. H. Brassey, M.V.O., Mr. R. J. Colman, Dr. Harry Corner, Mrs. Foot, Mr. John R. Keeble, Mr. J. H. Macdonald, Mr. John Maughan, Major Eric J. W. Platt, Mr. B. G. Shorten, Mrs. T. P. Warren, Mr. G. H. Willis and Mr. Hugh Wyllie.

Numbers on Register.

6. These and other changes bring the total number of governors and members on the Register to 7,824, as follows :—

147 Life governors,
186 Annual governors,
1,459 Life members,
6,011 Annual members,
21 Honorary members,
———
7,824 Total, which compares with 7,321 at the time of the last report.

President for 1947.

7. Lt.-Col. Sir Archibald Weigall, Bt., K.C.M.G., is recommended by the Council for election as President of the Society for 1947.

Changes in the Council.

8. Lt.-Col. Walter Burrell has been appointed a Vice-President in place of the late Mr. William Everall. Mr. Herbert Jones, of Hall Farm, Honington, Grantham, has been elected to fill a vacancy in the representation of Lincolnshire. Dr. W. G. Ogg, Mr. Henry Deck and Earl De La Warr have joined the Council as "Nominated" members.

Council Elections.

9. County elections by groups—which were not held during the war—are this year being resumed. Ordinary Councillors retiring by rotation at the next Annual General Meeting are those representing the electoral districts of Group "B," comprising Durham, Yorks. (West Riding), Nottingham, Leicester, Rutland, Suffolk, Buckingham, Essex, London, Shropshire, Hereford, South Wales, Devon, Wiltshire and Surrey. Governors and members registered in those districts have been notified and the procedure prescribed in the Bye-laws is being followed for the election or re-election of representatives to hold office for the next three years.

10. Elections are also taking place in the division of Gloucestershire, which, by virtue of its increased membership, is now entitled to a second representative ; in Staffordshire, through the resignation of Major Dyott ; in Yorks. (East Riding), through the resignation of Lord Middleton ; in North Wales, through the resignation of Major W. M. Dugdale ; and in Sussex, where a vacancy has occurred for an ordinary member of Council in consequence of the election of Lt.-Col. Walter Burrell as a Vice-President.

Lord Courthope's Services Acknowledged.

11. The Society's Gold Medal for distinguished services to agriculture, awarded in 1942 to Lord Courthorpe, was formally presented at the meeting of the Council held on the 11th September last, the delay in presentation being occasioned by the inability to obtain gold for the medal.

Lincoln Show.

12. The Council is pleased to record that permission has been obtained for the Society to hold a Show at Lincoln in 1947. The decision followed protracted negotiations with the Ministry of Agriculture and other government departments, whose sympathetic consideration of the Society's desires is hereby acknowledged. The Show will require to be restricted in size and scope, chiefly because of shortage of material and also of the demands upon labour for housing and other urgent problems. However, the Society is hopeful of being able to provide a worthy representation of livestock and displays of the new machinery which made possible the advance of British agriculture during the war. Special emphasis will be laid on the educational aspects of the Show and the results of recent agricultural research.

The showground, which has been placed at the Society's disposal by the City of Lincoln, will occupy 100 acres.

The preparation of the Stock Prize Sheet and Implement Regulations are well advanced and both will be issued as soon as possible.

13. Following on the decision to which reference was made in the last report of the Executive Committee, entries of cattle at Lincoln will be restricted to animals that have successfully passed the prescribed test for tuberculosis.

Contagious Abortion.

14. It is the Society's intention also to require that bovine animals be accepted for exhibition at the Royal Show of 1949 and subsequent shows of the Society *only* if satisfactory evidence is provided that they are free from contagious abortion.

A leaflet on contagious abortion is now in preparation and copies will shortly be ready for distribution.

Future Shows.

15. The intention to hold the second post-war Royal Show at Plymouth had to be reviewed in the light of discussions with Plymouth Corporation, following extensive war damage in the area. It was mutually agreed that the Society's visit should be postponed until conditions could be restored appropriately. The Council desires to record its sympathy with the Corporation of Plymouth in the losses they have suffered and looks forward to the fulfilment of the undertaking to stage a Royal Show there as soon as practicable.

16. A decision about the venue of the 1948 Show is still awaited. Unexpected difficulties have arisen in finding a ground at Shrewsbury. The alternatives of Shrewsbury and York are actively under consideration.

Award of " Victory " Medals.

17. During the past summer some 240 silver gilt "Victory" medals have been awarded by the Royal Agricultural Society to champion animals at the shows of the seventeen societies mentioned in the May edition of the *Quarterly*.

Inter-County Dairy Herds Competition.

18. The object of this competition for which the President, Lord Bledisloe, has generously given a handsome Trophy, is to recognise the dairy farmers of those counties which have made the most progress in eliminating tuberculosis from their herds. The Trophy, which was handed over by His Majesty the King at a Reception given by the President and Viscountess Bledisloe at the Goldsmiths' Hall on the 6th November, was won by the county of Carmarthen as having the largest number of Tuberculin-tested herds.

Conditions to govern the award of the Trophy in future years are now under consideration.

Young Farmers.

19. A Challenge Trophy has been awarded by the Society to the National Federation of Young Farmers' Clubs for annual competition on lines to be suggested by the Federation. The Council desires to record its appreciation of the valuable work of the movement and hopes that the Trophy will help to maintain and develop a high standard of craftsmanship and technical knowledge among members.

Argentine Judges.

20. The Society was honoured by an invitation from the Sociedad Rural Argentina to appoint judges for three breeds of cattle to act at the Palermo Show, Buenos Aires, in August, 1946, and was pleased to arrange for the following gentlemen to officiate :—

Finlay MacGillivray, Greenhead, Pencaitland, East Lothian. (*Shorthorns*).

Elwyn O. Jones, Sheep House, Hay, Hereford. (*Herefords*).

W. G. Macpherson, Mulben Mains, Mulben, Banff. (*Aberdeen-Angus*).

Awards for Long Service.

21. Since the last report of the Executive Committee medals and certificates have been awarded to the following for long service on farms :—

Years' Service.	
56	JOSEPH BIRD, Sutton Court Lodge, Pensford, Bristol.
56	JOHN HARRINGTON, Spains Hall, Finchingfield, Essex.
56	WALTER GEORGE PORTLOCK, Forge Cottage, Edgeworth, Stroud.
56	ARTHUR ERNEST WEBBER, Ston Easton, Bath, Somerset.
56	EDWARD CHARLES WILLS, Turnworth, Blandford, Dorset.
55	FREDERICK CHARLES BOLAND, The Lodge, Oak Hill College, Southgate, N. 14.
55	FRANK WILLIAM DENT, 55/56, Upper Harlestone, Northampton.
54	GEORGE ALFRED FAGG, Onion Beds Cottage, Woodnesborough, Kent.
54	CHARLES PARSONS, Wickmoor, Milverton, Somerset.
53	FREDERICK LESLIE GEORGE, 57, Great Brington, Northampton.
53	CHRISTOPHER WIFFEN, Duck End, Finchingfield, Essex.
52	WILLIAM CHARLES BOLT, Turnworth, Blandford, Dorset.
52	WILLIAM ERNEST JAMES, White Place Farm, Cookham, Berks.
51	ALBERT DARE, Duck End, Finchingfield, Essex.
51	JOHN WILLIAM NORTON, Post Office, Yanworth, Nr. Cheltenham, Glos.
51	WILLIAM HENRY PILL, Burncoose Lodge, Gwennap, Redruth, Cornwall.
51	RICHARD IVO WIGGINTON, Rolleston, Billesdon, Leicester
48	HARRY HEAD, Mooray, Chilmark, Salisbury, Wilts.
48	RICHARD MORRIS, The Green, Northop, Flintshire.
47	HARRY S. HILLYARD, Moxhill Farm, Cople, Bedford.
47	WILLIAM YEATES, The Street, Chilmark, Salisbury.
46	THOMAS CHARLES COOPER, Ham, Berkeley, Gloucester.
46	WILLIAM HENRY HINDER, Ham, Berkeley, Gloucester.
46	FREDERICK JESS RALLING, Second Lodge, Spains Hall, Finchingfield, Essex.
44	ARTHUR SPARROW, French's Farm, Barnardiston, Nr. Haverhill, Suffolk.
44	GEORGE SUCKLING, Duck End, Finchingfield, Essex.
43	HARRY WADE, Haughley, New Street, Nr. Stowmarket.
40	JESSE PEARCE, 20, Station Road, Chiseldon, Swindon.

22. For three years bronze was unobtainable for medals, but in recent months medals have been obtained and despatched to all who had qualified but had not received them. Additional publicity given to the terms of award, viz., forty years on the same or different holdings with one employer, or forty years on the same holding with different employers, has led to enlivened interest. Farm workers (male or female)—excluding gardeners, grooms and gamekeepers—in any part of England or Wales have hitherto been, and are still eligible. By resolution of the Council woodmen will in future also be eligible. A new design of medal is being prepared.

Chemical Department.

23. During the past year seventy-two samples have been submitted for examination by members of the Society.

Samples of water, soil, compound fertilisers and compound feeding stuffs constituted the greater part of those submitted. Little comment on these particular samples is necessary excepting to say that one sample of water submitted to know whether it was fit for drinking was about the worst sample Mr. Voelcker (the Society's Consulting Chemist) has ever examined. It was more of the nature of a weak sewage effluent. A sample of chick mash suspected of being the cause of death of 60 out of 100 chicks was found to be quite unsuitable for feeding purposes.

Of the miscellaneous samples submitted, an unknown white powder taken from a barrel and suspected of being plaster of paris, was found to be white lead, a most valuable find in these days of shortage. A sample of sea water damaged maize was considered suitable for feeding to poultry, and a sample of kiln dust (malt culms) was considered suitable for pig feeding, provided not more than 10 per cent. of the total ration consisted of this material. A sample of wafer biscuits which had been damaged by fire was submitted to know whether it could be used for feeding to pigs. The mass had become dextrinised in consequence of

the heat and had become quite rubbery in texture. However, it could be ground in a mill and when ground had quite a large power of absorption of liquids. It was proposed to use this material with bakers waste, but from experience this latter material invariably is sour and contains a large proportion of spent yeast together with pieces of sacking, mouldy flour, and general dirt. Apart from the actual examination of samples, many queries submitted by members have been answered and general advice given.

Botanical and Zoological.

24. The position created by the resignations of Sir Rowland Biffen and Mr. Cecil Warburton, announced in previous reports, has been under consideration, as there are still a number of members who prefer to obtain their information and advice through the Society. The Council has now decided to invite the co-operation of such bodies as the National Institute of Agricultural Botany and the Forestry Commission to ensure that members may be able to secure the best botanical or zoological advice procurable. To this end negotiations are proceeding, and the Council hopes to be able to announce details of the new arrangements at an early date.

Veterinary Department.

25. It is encouraging to note that during recent years members of the Society have availed themselves more freely of their privileges by consulting the Royal Veterinary College either directly or through their veterinary surgeons than was the case during the early years of the war and the College staff have freely given assistance in elucidating obscure disease problems and in suggesting means by which the incidence of various diseases might be prevented or controlled. The field covered by correspondence and consultations is wide and embraces most of the common diseases of farm stock such as the various forms of mastitis, contagious abortion, sterility, tuberculosis, Johne's disease and parasitism in cattle, swine fever, swine erysipelas, anaemia of piglets and nutritional disorders in pigs, abortion and parasitism in sheep and a variety of diseases in poultry. Several members of the Society take advantage of the services of the department of Preventive Medicine for the routine testing of blood and milk samples for the control of contagious abortion and mastitis.

Scheduled Animal Diseases. Briefly summarised it will be seen from the following comparative figures of the confirmed outbreaks of the scheduled diseases during the past five years, that in general there has been a decrease during the past year. In the case of Foot and Mouth disease there has been the usual fluctuation during the five-year period. The number of animals slaughtered under the Tuberculosis Order of 1938 has shown a steady and sustained decrease as has also the number of outbreaks of Anthrax. In the case of Swine Fever there has been some fluctuation but there has been a very satisfactory decrease in the number of outbreaks of Sheep Scab during the past year and in the number of outbreaks of Parasitic Mange during the past four years :—

Year.	*Anthrax.*	*Foot and Mouth Disease.*	*Parasitic Mange.*	*Sheep Scab.*	*Swine Fever.*
1942	320	502	32	235	471
1943	339	183	8	267	502
1944	203	95	9	222	1,140
1945	139	208	7	261	1,208
1946	100	52	7	91	501

Importations of Pedigree Livestock.

26. During the year, five boars and five sows of the Tamworth breed have been imported from Canada under the Importation of Pedigree Animals Act, 1925, and 90 head of pure-bred Canadian Holstein-Friesian Cattle have been imported under the Ottawa Agreements Act, 1932.

Exports to New Zealand.

27. In May Lord Bledisloe received the following information in a letter from Mr. Peter Fraser, Prime Minister of New Zealand :—

> " I have discussed with Mr. Roberts (Minister of Agriculture) the question of lifting the embargo on the direct importation of pedigree stock into New Zealand, and we are agreed that this is of the greatest importance to the Dominion. Before it can be done, however, a quarantine station must be established in Auckland to replace the one on Motuihi Island, which was taken over by the Naval authorities shortly after the outbreak of war. Every endeavour is being made to obtain a suitable site for this purpose, and negotiations are proceeding with a view to securing a portion of another island in the Auckland harbour.
>
> You may rest assured that every endeavour will be made to expedite the establishment of a quarantine station in Auckland, and when this is done the points raised by you will receive full consideration. I shall communicate with you again when a decision has been reached."

28. Reporting this to the Council, Lord Bledisloe explained that he had made a special appeal to the Prime Minister of New Zealand that, at any rate during his (Lord Bledisloe's) term as President of the Society, something effective might be done to lift the embargo. In New Zealand there was an unfounded and illogical fear of the conveyance of foot and mouth disease from this country, but the latency of the disease was so short that no animal could possibly carry it from this country to the Antipodes. Under the existing arrangements, all livestock sold by breeders in this country to breeders in New Zealand had to be detained in Canada for some weeks, with the result that the unfortunate New Zealander had to pay considerably more. The New Zealand Government had consented to the lifting of the embargo so far as detention in Canada was concerned ; in other words, there would now be direct transport of livestock to New Zealand, subject only to the replacement of the old New Zealand Quarantine Station by a new one on the coast near Auckland. He had made a strong appeal to the Prime Minister and to the acting Prime Minister, Mr. Walter Nash, to accelerate the provision of that station, and he had received an assurance from both that they would endeavour to do so. That could, he thought, be regarded as satisfactory.

National Diploma in Agriculture.

29. In 1946 two examinations for the National Diploma in Agriculture were held : for the first, at Edinburgh in April, 124 candidates appeared ; for the second, at Leeds in July, 294 candidates presented themselves. Following are the names of those who gained the Diploma—60 at Edinburgh and 79 at Leeds :—

EDINBURGH EXAMINATION.

Diploma.

BRIAN ANTHONY LINGARD ACKROYD, University of Leeds.
CHARLES DURNING AIKMAN, University of Glasgow and West of Scotland Agricultural College.
RONALD HUGH ALEXANDER, West of Scotland Agricultural College.
DAVID WILLIAM ANDERSON, West of Scotland Agricultural College.
WILLIAM ARNOLD ASHLEY, King's College.
IAN JOSEPH ASHWORTH, University of Leeds.
VICTOR JOHN DESMOND BALDRY, University of Leeds.
WILLIAM JOHN BASSETT, University of Leeds.
JACK BRADWELL, University of Leeds.
EDWARD WILLIAM BRIGNALL, University of Leeds.
JOHN WILSON BROWN, West of Scotland Agricultural College.
WILLIAM BUCHANAN, University of Glasgow and West of Scotland Agricultural College.
PETER BUCKLER, South Eastern Agricultural College.
MALCOLM EDWARD CASTLE, University of Leeds and West of Scotland Agricultural College.

Roy Keith Clarke, Midland Agricultural College.
Hugh Mackay Clarkson, Edinburgh and East of Scotland College of Agriculture.
William Sydney Clayton, Harper Adams Agricultural College.
Alan Clegg, King's College.
Peter John Coates, Midland Agricultural College.
David William Vincent Cross, Harper Adams Agricultural College.
Alastair Patrick Grant, Aberdeen University.
Harry Taylor Grant, University of Glasgow, West of Scotland Agricultural College and Midland Agricultural College.
Frank Braithwaite Hall, University of Reading.
John Ernest Harrison, Harper Adams Agricultural College.
James Donaldson Hendry, University of Glasgow and West of Scotland Agricultural College.
Charles Grahame Hoyte, Edinburgh and East of Scotland College of Agriculture.
Gerard Kelly, West of Scotland Agricultural College.
Bernard Law, University of Glasgow and West of Scotland Agricultural College.
Robert Austin Lewis, University of Leeds.
Charles Anthony Litt, Harper Adams Agricultural College.
George Lygo, 115, Station Road, Hatton, Derbyshire.
Dorothy Masters, Harper Adams Agricultural College.
Robert McBride, West of Scotland Agricultural College.
George Wyllie McHarg, West of Scotland Agricultural College.
Helen Christine McIver, University of Edinburgh, and Edinburgh and East of Scotland College of Agriculture.
Donald Neil McVean, University of Glasgow and West of Scotland Agricultural College.
Geoffrey Thomas Mollart, Midland Agricultural College.
Alexander McLaren Morton, West of Scotland Agricultural College.
Brian Jack O'Brien-Gore, Harper Adams Agricultural College.
Alexander Brian Pengilly, University of Leeds.
John Edward Pepper, Midland Agricultural College.
George William Edward Pickworth, Harper Adams Agricultural College.
George Pollock, Greenmount Agricultural College.
Dorothy Estelle Price, West of Scotland Agricultural College.
John Robinson Proud, University of Leeds.
John Dudley Reynolds, West of Scotland Agricultural College.
Elizabeth Ellen Richards, Harper Adams Agricultural College.
James Stewart Robertson, University of Glasgow and West of Scotland Agricultural College.
John Rogerson, University of Glasgow and West of Scotland Agricultural College.
Silvan Alexander Ross, West of Scotland Agricultural College.
Nigel Francis Sampson, Midland Agricultural College.
Peter Robert Scowcroft, University of Leeds.
Doreen Isobel Smith, Edinburgh and East of Scotland College of Agriculture.
Mary Waugh Steele, University of Glasgow and West of Scotland Agricultural College.
Marguerite Daphne Stevenson, Midland Agricultural College.
Josephine Elisabeth Taylor, Midland Agricultural College.
Dorothy Margaret Whyte, West of Scotland Agricultural College.
Geoffrey Delves Wilkinson, Midland Agricultural College.
James Wilson, West of Scotland Agricultural College.
Bryan Arthur Woodward, Midland Agricultural College.

Twenty-six candidates passed a first group of subjects.

Leeds Examination.

Diploma.

George Ronald Adams, Harper Adams Agricultural College.
Henry Dukesel Ainsley, University of Leeds.
Lucius Charles Arthur, Harper Adams Agricultural College.
John Leonard Bawtree, University of Reading.
David Hassall Beech, University of Leeds.
James Charles Ellingworth Bevin, Harper Adams Agricultural College.
Helen May Bowman, Midland Agricultural College.
Reginald Brill, Midland Agricultural College.
Neville William Broadhurst, Harper Adams Agricultural College.
David Calcott, University of Reading.
Graham Reid Carslaw, West of Scotland Agricultural College.
Mary D. Clark, West of Scotland Agricultural College.
Alison Mary Clarke, Midland Agricultural College.
Ian Watson Clewley, University of Reading.
Dennis Ritson Coldwell, King's College.

ALFRED WILLIAM COOPER, Harper Adams Agricultural College.
FRANK BRYAN COTTRELL, Harper Adams Agricultural College.
JOHN WILLIAM CHARLES COXON, Midland Agricultural College.
ERNEST WILLIAM GEORGE CROUCH, Seale-Hayne Agricultural College.
ALBERT DOCKER, Harper Adams Agricultural College.
MICHAEL FRANK DODD, Harper Adams Agricultural College.
*FRANCIS WILLIAM ELLIS, Essex Institute of Agriculture.
PETER FREDERICK FREEMAN, Seale-Hayne Agricultural College.
ALFRED ROY GALBRAITH, Seale-Hayne Agricultural College.
PETER CHARLES GRAVETT, Seale-Hayne Agricultural College.
ROSS FRANK DAVID HADDOW, Midland Agricultural College.
MALCOLM ROY HARRIMAN, Seale-Hayne Agricultural College.
EDWIN JOHN HETHERINGTON, King's College.
WILFRED LYNN HINTON, Harper Adams Agricultural College.
HENRY RICHARD HOLBOROW, University of Reading.
MILES HOLLAND-RAMSAY, Seale-Hayne Agricultural College.
GEOFFREY ROWLAND HOLMES, Midland Agricultural College.
REGINALD HARRY ISAAC, Midland Agricultural College.
TREVOR WILLIAM KEMSLEY, University of Reading.
IAN MORGAN KERR, Harper Adams Agricultural College.
RICHARD ALEXANDER LEACH, Seale-Hayne Agricultural College.
REGINALD JOSEPH LONGSTREET, Seale-Hayne Agricultural College.
WILLIAM MACKENZIE, University of Glasgow.
MARK MCLEAN, Midland Agricultural College.
PETER ALLEN MARSDEN, Midland Agricultural College.
JASON BASIL MERMIKIDES, University of Reading.
ROBERT WILLS MITTER, Seale-Hayne Agricultural College.
ALAN DEREK NORRIS, Seale-Hayne Agricultural College.
THOMAS OKEY, University of Reading.
ARTHUR DEREK PARKER, Seale-Hayne Agricultural College.
REX WILLIAM PICKFORD, Royal Agricultural College.
WILLIAM ERIC FRAME RANKIN, Harper Adams Agricultural College
JUNE RAYMENT, Seale-Hayne Agricultural College.
ALLEN FLETCHER REES, Seale-Hayne Agricultural College.
HUMPHREY GETHIN REES, Seale-Hayne Agricultural College.
KENNETH LAMBERT RICHARDS, Seale-Hayne Agricultural College.
BARRY MAXWELL ROBINSON, Harper Adams Agricultural College.
DOUGLAS FREDERICK LANGLEY ROSE, Harper Adams Agricultural College.
SYLVIA MARY RUSSELL, Midland Agricultural College.
PHILIP SHINGLER, Harper Adams Agricultural College.
PHILIP HENRY SHUCKSMITH, Midland Agricultural College.
GEORGE ROBERT SIGSWORTH, University of Leeds.
†PHILIP LIONEL d'E. SKIPWITH, Rapleys, Grazeley Green, Nr. Reading.
WALTER NORMAN SMITH, University of Leeds.
WILLIE SMITH, Seale-Hayne Agricultural College.
JEAN INSTONE SMITHEMAN, Harper Adams Agricultural College.
GORDON JAMES FARMER STEVENS, Seale-Hayne Agricultural College.
CLIFFORD STEVENSON, Midland Agricultural College.
ENA MARGARET STEWART, Midland Agricultural College
MICHAEL MENZIES STRANG, Harper Adams Agricultural College.
CHARLES KEITH SYKES, Midland Agricultural College.
JOSEPH DONALD SYKES, University of Leeds.
PETER WILLIAM TAYLOR, Midland Agricultural College.
PHILIP ARTHUR TAYLOR, Seale-Hayne Agricultural College.
KEITH JAMES THOMPSON, Midland Agricultural College.
JOHN WILLIAM THURLEY, Midland Agricultural College.
MICHAEL RICHARD WARNER, Midland Agricultural College.
MICHAEL CONRAD WELLER, Seale-Hayne Agricultural College.
DENNIS TANSLEY WESTON, Midland Agricultural College.
GEORGE HANSON WHITAKER, Seale-Hayne Agricultural College.
JERRY WHITE, Midland Agricultural College.
RICHARD JAMES WILLIS, West of Scotland Agricultural College.
GLADYS WILSON, Midland Agricultural College.
JAMES WYLLIE, University of Edinburgh.

Seventy-eight candidates passed a first group of subjects.

* Passed a first group of subjects while a prisoner-of-war in Germany.
† Passed in all papers while a prisoner-of-war in Germany; appeared at Leeds for oral examination only.

National Diploma in Dairying.

30. For the National Diploma in Dairying the 51st annual examination was held in September, at Reading for English and Welsh students, and at the Dairy School, Auchincruive, Ayr, for Scottish students. At the English centre 88 candidates were examined, of whom 42 were successful. Seventy-three candidates appeared at the Scottish centre, of whom 31 passed. Below are the names of the Diploma-winners:—

ENGLISH CENTRE.

HENRY JOHN BAKER, University of Reading.
ELISABETH ROSEMARY BROWN, Studley College.
SYLVIA MARY BURDFIELD, University of Reading.
SHEILA GRACE CHESHIRE, Midland Agricultural College.
MARGARET EVA CHISLETT, University of Reading.
ROSEMARY IMOGEN ATTERBURY CLUTTERBUCK, Studley College.
PATRICIA JOAN CULLEY, Midland Agricultural College.
KENNETH HENRY DEARDEN, Midland Agricultural College.
ROSEMARY RACHEL DERBYSHIRE, University of Reading.
ERNEST JOHANNES GLÜCKSMANN, West of Scotland Agricultural College.
MARY KATE GOLLEDGE, Midland Agricultural College.
STELLA JOAN HARVEY, University College of Wales, Aberystwyth.
MARY MARTIN HODDELL, University of Reading.
NANETTE JACKSON, Midland Agricultural College.
AUDREY JONES, University of Reading.
RENA JONES, University College of Wales, Aberystwyth.
MAUREEN CYNTHIA JOY, University College of Wales, Aberystwyth.
PETER GEORGE KAUFMANN, Seale-Hayne Agricultural College.
IRENE LAMB, Midland Agricultural College.
ELIZABETH ROBERTA ANN LANKESTER, Studley College.
MARY TERESA LIVESEY, University of Reading.
ROSALIND MACHIN, Midland Agricultural College.
MOLLIE MANSFIELD, Studley College.
BRENDA MARY ALLISON MARTIN, Midland Agricultural College.
MARY POPPY NUTT, Studley College.
JUDITH WYKEHAM PASSMORE. University of Reading.
SHEILA PEEL, University of Reading.
KATHLEEN JANET PHARAOH, Seale-Hayne Agricultural College.
JEAN ANN PICKERING, Studley College.
BRENDA PORTEOUS, University of Reading.
SUSAN MARGARET PRICE, University of Reading.
BARBARA ELIZABETH PRITCHARD, University College of Wales, Aberystwyth.
ISABEL MARGARET PYCROFT, Studley College.
MARJORIE GLADYS SAUNDERS, University College of Wales, Aberystwyth.
MAUDE DOROTHY SELFE, Studley College.
MARY SIMS, University of Reading.
VERA I. TARR, Seale-Hayne Agricultural College.
MURIEL PATRICIA WALLER, University of Reading.
RACHEL KATHARINE WARD-SMITH, Studley College.
ELIZABETH WIGMORE, University of Reading.
ALICE JESSIE WISE, University of Reading.
JEAN FERNANDES YEARDLEY, Midland Agricultural College.

SCOTTISH CENTRE.

JESSIE AITCHISON ANDERSON, Smeaton Shaw, Dalkeith, Midlothian.
SHEILA DUNCAN BLACK, 578, Pollokshaws Road, Glasgow, S. 1.
JAMES RONALD ADAM BLACKWOOD, "Nethercliffe," Alva, Clackmannanshire.
ELIZABETH BEDELL BOYD, 62, Manse Road, Bearsden, Dumbartonshire.
JACK BRADWELL, 50, Clarel Street, Penistone, Sheffield.
NORA BROOKS, Limehurst Farm, Waterloo, Ashton-under-Lyne, Lancs.
NORMA ELAINE BROWNLESS, 31, Ridgewood Crescent, South Gosforth, Newcastle-on-Tyne, 3.
ANN MACNAUGHTON CAMPBELL, Boreland, Fearnan, Aberfeldy, Perthshire.
JAMES MOIR GOLDIE, 29, Craigdhu Road, Milngavie, Dumbartonshire.
HELEN ELIZABETH HAGGART, Laggan, Crieff, Perthshire.
CATHERINE BOYD HOOD, 22, Emma Street, Blairgowrie, Perthshire.
W. JEAN AINSLIE JOHNSON, 29, Alexandra Road, Reading.
EFFIE MARGARET KITCHING, 6, Traquair Park West, Corstorphine, Edinburgh, 12.
THORBURN ALEXANDER THOMSON LEITCH, 22, Dean Terrace, Kilmarnock.

ROBERT MCBRIDE, Monktonhill, Prestwick.
MARY J. MACDONELL, Upperton, Buntait, Glen Urquhart, Inverness-shire.
DUNCAN GARNONS MACDOUGALL, Druimneil, Port Appin, Appin, Argyll.
THOMASINA MAIRI ROSS MCGHEE, The Pheasantry, Hartley Wintney, Basingstoke, Hants.
GEORGE WYLLIE MCHARG, Kirkland, Leswalt, Stranraer.
CHRISTINA ALENA MACINTYRE, Ardnadrochit, Auchnacraig, Mull.
ELSPETH MAUD MACLELLAN, 10, Sydenham Road, Glasgow, W.2.
JEAN HUNTER MAIR, 26, Lindsay Street, Kilmarnock.
MARJORIE SCURRAH MIDDLETON, Skelgill House, Askrigg, Leyburn, Yorks.
MARGARET ELSPETH BLYTH NEILL, Threave, Lasswade Road, Eskbank, Midlothian.
JEAN KIRSTY NICHOLL, Langenhoe Hall, Langenhoe, Colchester, Essex.
ELEANOR STIRLING POWELL, 54, Kings Road, Rosyth, Fife.
MARION COPLAND SPENCE, Braefoot, Langbank, Milngavie, Dumbartonshire.
MARY WAUGH STEELE, Blackhill Farm, Crossford, Carluke, Lanarkshire.
ALFRED WALSH, Paa Farm, Paythorne, Gisburn, Nr. Clitheroe, Lancs.
WILLIAM ARTHUR WALSH, 10, St. Peters Road, Petersfield, Hants.
JAMES WILSON, Brockwellmuir, Dunlop, Kilmarnock.

All the candidates at the Scottish Centre had been students at the Dairy School for Scotland, Auchincruive, Ayr.

31. The Regulations and Syllabus for both the N.D.A. and N.D.D. Examinations are being revised. The new conditions cannot be operative before 1948.

32. Questions relating to the National Diplomas have been discussed with the Ministry of Agriculture in the light of observations of the Loveday Committee on Higher Agricultural Education. The Council is firmly of opinion that the Diploma examinations have served and can continue to serve a most valuable purpose, though, as already indicated, there is need for some revision of conditions to meet changed circumstances.

Medals for Cattle Pathology.

33. In the annual examination conducted by the Royal Veterinary College in 1946 the Society's Silver and Bronze medals for Cattle Pathology were awarded to F. C. Startup, 67, Granville Road, Bromley, Kent, and to T. R. B. Lewis, Cwmbran, Llanwrda, Carmarthen.

Journal.

34. Volume 106 of the Society's *Journal* was circulated to members at the beginning of 1946. Volume 107 is now in preparation: it is hoped that it will be ready for issue in the New Year.

The Council is pleased to have enlisted the services as Editor of Dr. Charles Crowther, whose work as an agricultural educationist is well known.

Quarterly Bulletin.

35. Three issues of the *Quarterly Bulletin* have appeared in 1946; another is due to be circulated to members before the end of the year. Consideration is being given to the possibilities of developing this publication, which was started in January, 1945, as a means of keeping members informed of the Society's activities.

Fream's "Elements of Agriculture."

36. The Society's valuable text-book "Elements of Agriculture" is in process of being thoroughly revised and brought up to date under the general editorship of Dr. G. H. Robinson of Worcester. The intention is that the book shall again constitute a thoroughly comprehensive survey of those departments of agriculture which the aspiring student, no less then the practical farmer, can turn to for guidance.

Library.

37. A committee has been appointed to report on the Society's library at 16, Bedford Square and to make recommendations as to the steps necessary to bring it up-to-date, and also to improve the facilities which the library can offer to members.

Queen Victoria Gifts Fund.

38. For the fourth successive year there were no unsuccessful applicants for pensions at the 1946 election of the Royal Agricultural Benevolent Institution. The Trustees of the Fund were again precluded from making their annual grants, and the amount available is being retained for future grants.

International Conference of Agricultural Producers.

39. At its meeting in June the Council expressed its appreciation of the successful efforts made by the National Farmers' Union in connection with the International Conference of Agricultural Producers in the following resolution :—

> That the Royal Agricultural Society of England convey to the National Farmers' Union warm congratulations on their enterprise and vision in organising the International Conference of Agricultural Producers and on the outstanding success which attended it.

The Society is heartily in sympathy with this movement towards agricultural unity, and it was more than a gesture of hospitality that prompted the President to invite the conference delegates to a Reception at the Goldsmiths' Hall on 27th May. Lord Bledisloe, in his address to them, said : " Let me assure you that our Society recognises now as never before that the economic welfare of your several rural populations (and the contentment and happiness which flow from it) is inseparably bound up with our own."

Farm Weeks.

40. The Council has been very pleased to co-operate with the National Farmers' Union in the organisation of the Union's " Farm Weeks." Joint meetings with the N.F.U. and representatives of the implement and machinery manufacturers, held uuder the auspices of the Society, led to the staging of useful and comprehensive displays of machinery at Nottingham and Bristol.

President's Appeal to Members.

41. At the Council Meeting in June the President made an appeal to the general body of the Society's members throughout the country at a crisis in the country's history, when they were faced with the prospect of the most serious food shortage which the country had ever known. Members would, he felt sure, share his view that there rested upon the Society a grave responsibility to promote by every means in its power the maximum output of food from the soil, especially in the critical years 1947 and 1948. The President concluded his appeal as follows : " Let us use our best endeavours on our farms, on our estates, on County Agricultural Executive Committees, and amongst our neighbours, to merit the confidence of the nation by bending our energies to the fulfilment of this patriotic duty."

Presentation to Mr. T. B. Turner.

42. Mr. Thomas Blundell Turner, M.V.O., Secretary to the Society since 1921, retired on the 30th March, 1946. At the Council's meeting on the 6th March, Mr. Turner was elected an Honorary Life Governor and presented with a clock in recognition of his services to the Society.

Sir Roland Burke, Honorary Director of the Royal Show since 1931, paid a tribute to Mr. Turner's organising abilities and to his adaptability in emergencies. He said that Mr. Turner had both given of his best and had at all times endeavoured to uphold the great traditions of the Society ; his management of the secretarial duties connected with the Show had been outstanding. The association with Mr. Turner had been a happy one—Presidents, members of Council and everyone connected with the Society would always remember with gratitude the loyal service he had rendered.

43. Mr. Alec Hobson, who was appointed Secretary to succeed Mr. Turner, commenced his duties on the 1st April, 1946.

Return of Staff.

44. The Council has been pleased to welcome back from the armed forces Mr. E. R. Slade and Mr. F. R. Francis, members of the Society's office staff, after several years' active service.

By order of the Council,

ALEC HOBSON,

Secretary.

16, Bedford Square,
London, W.C. 1.

6th November, 1946.

Presentation of Inter-County Dairy Herds Trophy 6th November, 1946

Their Majesties the King and Queen conferred a signal honour upon the Society when, on November 6th, 1946, they attended a Reception given by the President, Viscount Bledisloe, and Viscountess Bledisloe at the Goldsmiths' Hall in the City of London, where the King presented the Inter-County Dairy Herds Trophy, won by Carmarthenshire, and handed the Society's long service medals to twenty-two veteran farm workers who had served their employers loyally for upwards of forty years.

Welcoming Their Majesties, Viscount Bledisloe explained how the Society had decided to allow no tuberculous bovine animal to enter the Royal Showyard in the future and to inaugurate an Inter-County Dairy Herds Competition, the award in the form of a trophy being made to the County in England or Wales showing the greatest progress in eliminating tuberculosis from its dairy herds. Although it was hoped to draft a scheme which would in future years give definite encouragement to those counties which could show the largest annual increase in the number of their tuberculin tested dairy herds, it had been decided this year to award the trophy to the County possessing (according to the Milk Marketing Board's records) the largest number of tuberculin tested dairy herds. This was Carmarthenshire (with 3,210), the next in order of priority being Cardiganshire (with 1,913) and Pembrokeshire (with 1,310).

In presenting the trophy to Mr. T. Walters of St. Clears, Carmarthen, representing the winning county and who was the first milk producer in the whole of Wales to have an Attested Herd, His Majesty congratulated the county of Carmarthenshire and the whole principality of Wales on the lead they had given in the movement for the purification of the country's milk supplies.

Mr. Tom Williams (Minister of Agriculture and Fisheries), in tendering thanks to His Majesty for presenting the awards, said the presence of Their Majesties would have an effect far beyond the bounds of the gathering. Mr. Williams paid tribute to the work of the Royal Agricultural Society of England and made reference to the generosity of the President, Viscount Bledisloe, for having given the trophy which His Majesty had presented.

Royal Agricultural Society of England

(*Established May 9th*, 1838, *as the* ENGLISH AGRICULTURAL SOCIETY, *and incorporated by Royal Charter on March 26th*, 1840).

Patron.

HIS MOST GRACIOUS MAJESTY THE KING

President for 1947.

LT.-COL. SIR ARCHIBALD G. WEIGALL, BT., K.C.M.G.

Trustees.

Year when first elected on Council	
1935	H.R.H. THE DUKE OF GLOUCESTER, K.G., P.C., *York House, St. James's Palace, S.W.*1.
1940	ATHLONE, Earl of, K.G., P.C., *Kensington Palace, S.W.*
1921-29 1935	BLEDISLOE, Viscount, P.C., G.C.M.G., K.B.E., *Lydney Park, Glos.*
1918	BURKE, SIR ROLAND, K.C.V.O., *Melton Mead, Woodbridge, Suffolk.*
1921	BURRELL, Sir MERRIK R., Bt., C.B.E., *Floodgates, West Grinstead.*
1921	COURTHOPE, Lord, P.C., M.C., *Whiligh, Walcrouch, Sussex.*
1911-17 1926	HASTINGS, Lord, *Melton Constable Park, Norfolk.*
1909	HAZLERIGG, Lord, *Noseley Hall, Leicester.*
1914	POWIS, Earl of, *Powis Castle, Welshpool, Mont.*
1934	STRADBROKE, Earl of, K.C.M.G., C.B., C.V.O., C.B.E., *Henham Hall, Wangford, Beccles*
1925	WEIGALL, Lt.-Col. Sir ARCHIBALD G., Bt., K.C.M.G., *Englemere, Ascot, Berks.*

Vice-Presidents.

1922	BELL, JOHN, *The Hall, Thirsk, Yorks.*
1931	BURRELL, LT.-COL. WALTER R., M.B.E., T.D., D.L., *Knepp Castle, Horsham.*
1938	CRANWORTH, Lord, M.C., *Grundisburgh Hall, Woodbridge, Suffolk.*
1908	DERBY, Earl of, K.G., P.C., *Knowsley, Prescot, Lancashire.*
1935	DIGBY, Lord, D.S.O., M.C., *Cerne Abbey, Dorchester.*
1913	EVENS, JOHN, *Burton, Lincoln.*
1924	EVERARD, Sir W. LINDSAY, *Ratcliffe Hall, Leicester.*
1929	HAREWOOD, Earl of, K.G., *Harewood House, Leeds.*
1927	NEAME, THOMAS, *The Offices, Macknade, Faversham.*
1942	NORFOLK, Duke of, K.G., P.C., *Arundel Castle, Sussex.*
1928	RADNOR, Earl of, K.C.V.O., *Longford Castle, Salisbury.*
1907	SMITH, FRED, *Deben Haugh, Woodbridge, Suffolk.*

Ordinary Members of the Council.

1922	ALEXANDER, HUBERT, *Gileston Manor, St. Athan* (*Glamorgan*).
1939	ARGLES, CECIL G., *Sibson House, Wansford, Peterborough* (*Westmorland*).
1937	BAIRD, Capt. W. J., *Ranksborough Hall, Oakham* (*Rutland*).
1945	BARCLAY, Major M. E., *Beaches Manor, Brent Pelham, Buntingford* (*Hertfordshire*).
1937	BELCHER, J. MORRIS, *Tibberton Manor, Wellington* (*Shropshire*).
1946	BENNION, JOHN E., *Home Farm, Stackpole, Pembroke* (*South Wales*).
1930	BENYON, HENRY A., *Englefield House, near Reading* (*Berkshire*).
1939	BLEWITT, Lt.-Col. GUY, D.S.O., M.C., *Boxted Hall Farms, Colchester* (*Essex*).
1936	BOURNE, JOHN, *Snowshill Hill, Moreton-in-Marsh* (*Gloucestershire*).
1936	CATOR, Lt.-Col. H. J., M.C., *Woodbastwick Hall, Norwich* (*Norfolk*).
1946	CHILLINGWORTH, CHARLES A., *Barton Farm, Siddington, Cirencester* (*Gloucestershire*).

Ordinary Members of the Council—(*continued*).

Year when first elected on Council	
1943	Cornwallis, Lord, K.B.E., M.C., *Plovers, Horsmonden, Paddockwood (Kent).*
1946	Coxon, Charles L., *Milton, Shobdon, Leominster (Herefordshire).*
1938	Cullimore, Charles, *Christleton, Chester (Cheshire).*
1947	*Dallas, George, C.B.E., J.P., *Strathclyde, Great Doddington, Northants.*
1921	*Dampier, Sir W. C. D., Sc.D., F.R.S., *Upwater Lodge, Cambridge.*
1946	Dawe, R. W. N., *Alrewas Hayes, Burton-on-Trent (Staffordshire).*
1946	*Deck, Henry, *Orwell Works, Ipswich.*
1946	*De La Warr, Earl, P.C., *Fishers Gate, Withyham, Sussex.*
1942	Duberly, Capt. E. H. J., M.C., *Staughton Manor, St. Neots (Huntingdonshire).*
1946	Dunnington-Jefferson, Lieut.-Col. Sir John, D.S.O., *Thicket Priory, Thorganby, York (Yorks. E. Riding).*
1936	Egerton, Commdr. H. Sydney, D.S.C., R.N., *Mountfield Court, Robertsbridge (Sussex).*
1929	Elgin, Earl of, K.T., *Broomhall, Dunfermline (Scotland).*
1933	Everett, Major Norman, *Rushmere, Ipswich (Suffolk).*
1928	Forshaw, Thomas, *The Stud, Carlton-on-Trent, Newark (Nottinghamshire).*
1935	Foster, Major Gordon B., *Leysthorpe, Oswaldkirk, York (Yorks., N. Riding).*
1931	Glossop, C. W. H., M.P., *Bramwith Hall, near Doncaster (Yorks., W. Riding).*
1945	Grafton, Duke of, *Euston Hall, Thetford (Suffolk).*
1946	Griffith, Major E. G. E., *Plas Newydd, Trefnant, Denbighshire (North Wales).*
1941	Haddon, R. W., C.B.E., *Dorset House, Stamford Street, S.E.1. (London).*
1925	Hale, Windham E., *Grimsargh House, Grimsargh, Preston (Lancashire).*
1939	Harris, John Frederick, *The Old Tower, Brackenburgh, Penrith (Cumberland).*
1945	Hazlerigg, Major The Hon. Arthur, M.C., *The Oaklands, Breach Lane, Earl Shilton, Leicester (Leicestershire).*
1919	Hobbs, Robert, *Kelmscott, Lechlade, Glos (Oxfordshire).*
1946	Hudson, The Rt. Hon. R. S., C.H., M.P., 18, *Cowley Street, Westminster, S.W.1. (London).*
1942	Hurd, Anthony R., M.P., *Rainscombe Farm, Oare, Marlborough (Wiltshire).*
1931	Jervoise, Major F. H. T., *Herriard Park, Basingstoke (Hampshire).*
1923	Johnstone, G. H., O.B.E., *Trewithen, Grampound Road (Cornwall).*
1946	Jones, Herbert, C.B.E., *Hall Farm, Honington, Grantham (Lincolnshire).*
1932	Kilpatrick, James, *Craigie Mains, Kilmarnock (Scotland).*
1944	Leigh, Lord, *Stoneleigh Abbey, Kenilworth (Warwickshire).*
1940	Merson, Tom H., *Farringdon, North Petherton, Bridgwater (Somerset).*
1946	The Lord Mildmay of Flete, *Flete, Ivybridge (Devonshire).*
1932	*Nicholson, A. C., *Trent Ironworks, Newark, Notts.*
1946	*Ogg, Dr. W. G., M.A., *Rothamsted Experimental Station, Harpenden, Herts.*
1945	Pease, Major Philip I., *Sledwich, Barnard Castle (Durham).*
1943	Pender, Major H. Denison, D.S.O., M.C., *Strangways, Marnhull, Sturminster Newton (Dorset).*
1935	Robertson, William, *Stamford, Alnwick (Northumberland).*
1937	Robinson, J. C. E., F.S.I., 15a, *St. Paul's Square, Bedford (Bedfordshire).*
1927	*Russell, Sir John, O.B.E., D.Sc., F.R.S., *Campsfield Wood, Woodstock, Oxfordshire.*
1946	Shirley, J. W., *Pear Tree Farm, Woughton-on-the-Green, Bletchley (Buckinghamshire).*
1933	Stedman, Sir L. Foster, *The Garth, Bassaleg, Newport (Monmouthshire).*
1938	Stopford-Sackville, N. V., *Drayton House, Lowick, Kettering (Northamptonshire).*
1929	Strafford, Earl of, *Wrotham Park, Barnet (Middlesex).*
1938	Talbot-Ponsonby, A. H. B., *Hinton Woodlands, Bramdean, Alresford (Hampshire).*
1946	Tupper, Captain Henry, M.C., *Bignor, Pulborough (Sussex).*
1947	*Turner, James, *West Bank Farm, South Anston, nr. Sheffield.*
1933	Walker, Sir Ian, Bt., *Osmaston Manor, Derby (Derbyshire).*
1933	Walker, John, *Knightwick Manor, Worcester (Worcestershire).*
1943	Watney, Bertram W. A., *Brookwood Corner, Holmwood (Surrey).*
1929	Webb, S. Owen, *Streetly Hall, West Wickham (Cambridgeshire).*
1938	Wiglesworth, R. T., *Stubble Hill, Harrietsham, Kent (Cheshire).*
1938	Wright, R. K., *Kilkea, Mageney, Co. Kildare (Ireland).*

* Nominated Member of Council.

STANDING COMMITTEES.

*** Under Bye-Law 73, the PRESIDENT is a Member *ex officio* of all Committees, and the TRUSTEES and VICE-PRESIDENTS are Members *ex officio* of all Standing Committees except the Committee of Selection and General Purposes.

Finance Committee.

HAZLERIGG, Lord (*Chairman*)
RADNOR, Earl of
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
CORNWALLIS, Lord
COURTHOPE, Lord
DE LA WARR, Lord
STEDMAN, Sir L. F.
WEIGALL, Sir ARCHIBALD
ALEXANDER, H.
BELL, JOHN
GLOSSOP, C. W. H.
HUDSON, R. S.
HURD, ANTHONY R.
TALBOT-PONSONBY, A. H. B.

Journal and Education Committee.

NEAME, T. (*Chairman*)
DE LA WARR, Earl
RADNOR, Earl of
HAZLERIGG, Lord
HAZLERIGG, Major Hon. A.
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
DAMPIER, Sir W. C. D.
RUSSELL, Sir JOHN
ARGLES, CECIL
BURRELL, Lt.-Col. W. R.
GLOSSOP, C. W. H.
HADDON, R. W.
HUDSON, R. S.
HURD, A. R.
SHIRLEY, J. W.

Chemical Committee.

(*Chairman*).
BLEDISLOE, Viscount
CRANWORTH, Lord
DAMPIER, Sir W. C. D.
RUSSELL, Sir JOHN
EVERETT, Major N.
HALE, W. E.
JERVOISE, Major F. H. T.
OGG, DR. W. G.
ROBERTSON, W.
ROBINSON, J. C. E.
SMITH, FRED

Forestry and Biological Committee.

HASTINGS, Lord (*Chairman*)
HAZLERIGG, Lord
HAZLERIGG, Major Hon. A.
BOURKE, Hon. G. J.
BURKE, SIR ROLAND
COURTHOPE, Lord
BENYON, H. A.
BOURNE, JOHN
BURRELL, Lt.-Col. W. R.
NEAME, T.
EELES, Lt.-Col. H. S.
EGERTON, Commdr. H. S.
GARDNER, R. C. B.
JERVOISE, Major F. H. T.
TALBOT-PONSONBY, A. H. B.
THOMPSON, C. H.
WIGLESWORTH, R. T.
LE SUEUR, A.D.C., F.R.I.C.S., B.Sc.

Veterinary Committee.

BURRELL, Sir MERRIK (*Chairman*)
RADNOR, Earl of
DIGBY, Lord
MILDMAY OF FLETE, Lord
BURKE, Sir ROLAND
SHELLEY, Sir J. F.
STEDMAN, Sir L. F.
WEIGALL, Sir ARCHIBALD
BARCLAY, Major M. E.
BELL, JOHN
BENNION, J. E.
BLEWITT, Lt.-Col. GUY
BURRELL, Lt.-Col. W. R
BUXTON, Prof. J. BASIL
COXON, C. L.
FOSTER, Major G. B.
GLOSSOP, C. W. H.
HARRIS, J. F.
HOBBS, ROBERT
JOHNSTONE, G. H.
PEASE, Major P.
ROBERTSON, W.
SMITH, FRED
TUPPER, Capt. H.
WALKER, JOHN
WIGLESWORTH, R. T.

Committee of Selection and General Purposes.

COURTHOPE, Lord (*Chairman*)
DIGBY, Lord
THE PRESIDENT
CORNWALLIS, Lord
WEIGALL, Sir ARCHIBALD
GLOSSOP, C. W. H.
SMITH, FRED

And the Chairman of each of the Standing Committees.

Research Committee.

DAMPIER, Sir W. C. D. (*Chairman*)
DE LA WARR, Earl
RADNOR, Earl of
BLEDISLOE, Viscount
CRANWORTH, Lord
HASTINGS, Lord
HAZLERIGG, Major Hon. A.
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
RUSSELL, Sir JOHN
BURRELL, Lt.-Col. W. R.
NEAME, T.
BENNION, J. E.
CATOR, Lt.-Col. H. J.
CULLIMORE, C.
HOBBS, ROBERT
HURD, A. R.
MERSON, Tom H.
OGG, Dr. W. G.
ROBINSON, J. C. E.
SMITH, FRED

Stock Prizes Committee.

BLEWITT, Lt.-Col. GUY (*Chairman*)
CRANWORTH, Lord
DIGBY, Lord
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
DUNNINGTON-JEFFERSON, Lt.-Col. Sir JOHN
EVERARD, Sir LINDSAY
LEIGH, Lord
MILDMAY OF FLETE, Lord
STEDMAN, Sir L. F.
WALKER, Sir IAN
WEIGALL, Sir ARCHIBALD
ARGLES, CECIL
ALEXANDER, H.
BAIRD, Capt. W. J.
BELCHER, J. MORRIS
BELL, JOHN
BURRELL, Lt.-Col. W. R.
EVENS, JOHN
BENNION, J. E.
CHILLINGWORTH, C. A.
COXON, C. L.
EVERETT, Major N.
FORSHAW, T.
FOSTER, Major G. B.
GLOSSOP, C. W. H.
HADDON, R. W.
HARRIS, JOHN F.
HOBBS, ROBERT
JONES, HERBERT
KILPATRICK, JAMES
MERSON, TOM H.
PENDER, Major DENISON
ROBERTSON, W.
SHIRLEY, J. W.
SMITH, FRED
TUPPER, Capt. HENRY
WALKER, JOHN
WEBB, S. OWEN
The Stewards of Live Stock

Judges Selection Committee.—*Same as Stock Prizes Committee.*

Implement Committee.

BELL, JOHN (*Chairman*)
RADNOR, Earl of
CORNWALLIS, Lord
BURKE, Sir ROLAND
COURTHOPE, Lord
DAMPIER, Sir W. C. D.
STEDMAN, Sir L. F.
BARCLAY, Major M. E.
CATOR, Lt.-Col. H. J.
DAWE, R. W. N.
DECK, HENRY
DUBERLY, Capt. E. H. J.
EVENS, JOHN
EVERETT, Major N.
HADDON, R. W.
JONES, HERBERT
NICHOLSON, A. C.
PEASE, Major P.
ROBERTSON, W.
TUPPER, Capt. HENRY
WEBB, S. OWEN
WRIGHT, S. J.,

Showyard Works Committee.

BURKE, Sir ROLAND (*Chairman*)
HAZLERIGG, Lord
BURRELL, Sir MERRIK
DUNNINGTON-JEFFERSON, Lt.-Col Sir JOHN
LEIGH, Lord
STEDMAN, SIR L. F.
BAIRD, Capt. W. J.
BELL, JOHN
BLEWITT, Lt.-Col. GUY
BOURNE, JOHN
BURRELL, Lt.-Col. W.R.
CHILLINGWORTH, C. A
DECK, HENRY
EVERETT, Major N.
FOSTER, Major G. B.
GLOSSOP, C. W. H.
HARRIS, JOHN F.
HOBBS, ROBERT
JONES, HERBERT
MERSON, TOM H.
NICHOLSON, A. C.
PENDER, Major DENISON
TALBOT-PONSONBY, A. H. B.
WEBB, S. OWEN
WIGLESWORTH, R. T.

Dairy and Produce Committee.

(*Chairman*)
BURKE, Sir ROLAND
BURRELL, Sir MERRIK
DAMPIER, Sir W. C. D.
WEIGALL, Sir ARCHIBALD
BARCLAY, Major M. E.
BENNION, J. E.
EGERTON, Commdr. H. S.
EVENS, JOHN
GLOSSOP, C. W. H.
JOHNSTONE, G. H.
KAY, Dr. H. D.
MACKINTOSH, J.
SHIRLEY, J. W.
SMITH, FRED

Horticultural Committee.

HAZLERIGG, Lord (*Chairman*),
BURKE, Sir ROLAND
PENNELL, W. E.

Honorary Director of Show.—SIR ROLAND BURKE, K.C.V.O.

Surveyor to Show.—CHARLES H. R. NAYLOR, *St. Mary's Chambers, Queen Street, Derby.*

Society's Officers.

Secretary.—ALEC HOBSON, O.B.E., 16, Bedford Square, London, W.C.1.

Editor of Journal.—DR. CHARLES CROWTHER, 79, *Cheam Road, Ewell, Surrey.*

Consulting Chemist.—ERIC VOELCKER, A.R.C.S., F.R.I.C., 1, *Tudor Street, London, E.C.4*

Consulting Veterinary Surgeon.—Prof. J. BASIL BUXTON, M.A., F.R.C.V.S., *Royal Veterinary College.*

Publisher.—JOHN MURRAY, 50, *Albemarle Street, W.1.*

Solicitors.—GARRARD, WOLFE & Co., 18, *St. James's Place, S.W.1.*

Bankers.—WESTMINSTER BANK LTD., 1, *St. James's Square, S.W.1.*

INDEX TO VOLUME 107

1946

The titles of Articles are printed in Italics.